Appendix D

Earthquake source parameters for southern California tomography

Note

This appendix is devoted to explaining the details of the 294 earthquakes listed in Figures D.1–D.37. Details regarding the selection of sources are discussed in Chapter 6.

Description of Figures D.1–D.37

We have two objectives in assembling focal mechanisms from previously studied earthquakes:

1. to obtain the best possible source parameters for our SEM-based source inversions or for our tomographic inversion;

2. to test the differences among various source-inversion approaches (Section 6.2.2) by comparing 3D synthetics directly with data.

Figures D.1–D.37 is a compilation of focal mechanisms for 294 earthquakes in southern California. The earthquakes are sorted by region, and, within each region, by origin time. Many of the earthquakes occur in aftershock sequences, so this ordering allows one to readily identify differences within the same sequence.

Each of the 294 earthquakes is classified into one of the six groups in Table D.1. The majority of the "extra" and "outside" sources are primarily from a set of 159 well-studied

Table D.1: Classification groups for all 294 earthquakes in Figures D.1–D.37.

label	number	description
TOMO	143	used in at least one iteration of the tomographic inversion
EXTRA	91	not used in the tomographic inversion
LOW SNR	28	low signal-to-noise ratio
OUTSIDE	16	outside simulation region
REJECTED	9	rejected
BAD SOURCE	7	wrong source mechanism

earthquakes of *Tan* (2006, Appendix A).

The "low SNR" earthquakes are primarily events that generate synthetic seismograms that have measurement windows (*Maggi et al.*, 2009) at fewer than 10 stations. In regions that are very challenging to determine source parameters—for example, Continental Borderlands and Salton trough—I have moved some low signal-to-noise earthquakes in the "extra" group, if the comparison with data suggested that the focal mechanism was "in the ballpark". I have left the "low SNR" earthquakes in the compilation for completeness, but most of these earthquakes are not quality events and are probably not worth investigating any further.

The "rejected" earthquakes are primarily events that occurred close in space, time, and magnitude to other events. These were typically determined by analyzing near-source records and identifying coherent seismic energy later in the same seismograms. Each secondary event was confirmed using the Southern California Earthquake Data Center catalog. I also rejected earthquakes that were clearly too large for a point-source approximation, given our period range of interest (2–30 s), such as the 2004.09.28 M_{w} 6.2 Parkfield earthquake (14094992).

The "bad source" earthquakes are events that appear to have data with high enough signal-to-noise ratio, but that clearly have the wrong source parameters. It is possible that better mechanisms could be determined with additional source inversion attempts, such as *Liu et al.* (2004).

Figures D.1–D.37 contains eight columns, which are described in Table D.2.

The "CAP" mechanisms are primarily from the set of 159 in *Tan* (2006), with 20 additional mechanisms provided by Shengji Wei (Caltech, December 2008). These 20 events are: 10006857, 10148421, 11671240, 12659440, 14073800, 14077668, 14138080, 14178236,

Table D.2: Eight columns of Figures D.1–D.37

column	label	description	reference
1	CAP	cut-and-paste method	*Tan* (2006)
2	JH	P/S amplitude ratio method	*Hardebeck and Shearer* (2003)
3	SCEDC	SCEDC	*Clinton et al.* (2006)
4	mod	SCEDC-modified	*Clinton et al.* (2006)
5	SEMm00	SEM inversion using $\mathbf{m}_{00}$	*Liu et al.* (2004)
6	m12	source parameters for $\mathbf{m}_{12}$	
7	SEMm12	SEM inversion using $\mathbf{m}_{12}$	*Liu et al.* (2004)
8	m16	source parameters for $\mathbf{m}_{16}$	

14179288, 14179292, 14186612, 14239184, 3320736, 9111353, 9112735, 9117942, 9154092, 9967901, 14383980, and 14408052.

The "mod" mechanisms only differ from "SCEDC" in cases where Egill Hauksson tried the inversion of *Clinton et al.* (2006) using different stations. These were cases where I identified poor agreement between data and 3D synthetics generated using the SCEDC mechanism. These events include: 10230869, 13970876, 13966672, 14072464, 9944301, 14179288, 14179292, 14263712, 9753485, 9755013, and 14178236.

The "SEMm00" inversions required an initial-guess focal mechanisms, which was taken to be the SCEDC mechanism in all cases except for 14263712, which used the modified SCEDC mechanism ("mod").

For the labels at the right, the numbers N1, N2, and N3 in "m16 : N1 (N2, N3, N4)" are given by:

N1	total number of stations with measurements for model $\mathbf{m}_{16}$
N2	number of stations with measurements for periods 6–30 s for $\mathbf{m}_{16}$
N3	number of stations with measurements for periods 3–30 s for $\mathbf{m}_{16}$
N4	number of stations with measurements for periods 2–30 s for $\mathbf{m}_{16}$

The label for each earthquake at the left of each row contains the event ID with a tag denoting two items: (1) the dataset providing the hypocenter and origin time; (2) the dataset providing the focal mechanism. The datasets for the hypocenters and origin times are:

label	reference
Salton	*Lohman and McGuire* (2007)
Parkfield	*Thurber et al.* (2006)
SanSimeon	*McLaren et al.* (2008), courtesy of Jeanne Hardebeck
Lin	*Lin et al.* (2007a), plus 18 from Guoqing Lin
NCEDC	NCEDC catalog
SCEDC-Loc	SCEDC local catalog
SCEDC-Reg	SCEDC regional catalog

The data sources for the focal mechanisms are:

label	reference
SEMm00	SEM inversion with model $\mathbf{m}_{00}$ (unpublished)
CAP	*Tan* (2006), plus 20 by Shengji Wei
JH	*Hardebeck and Shearer* (2003)
SCEDCmod	SCEDC with Hauksson modifications, if available
SEMm12	SEM inversion with model $\mathbf{m}_{00}$ (unpublished)
CHT	Carl's replacement after synthetic tests (unpublished)

For example, the label `9718013_SEMm12_Lin` denotes event 9718013, focal mechanism and modified depth from the SEM inversion using $\mathbf{m}_{12}$, and origin time, epicenter, and initial depth from *Lin et al.* (2007a).

The eight "CHT" events (10061489, 9119414, 14139160, 9154233, 9722669, 9817605, 13966672, 9660449) are events that initially generated poor fits to the data, but which had other proximal events (in time, space, and magnitude) with *different* mechanisms that produced much better fits. In these cases, I assigned the "other" event's focal mechanism to the CHT event, then generated 3D synthetics to verify that the new mechanism was better. One dramatic example of improvement is for 9817605, an event in the Salton trough. Mechanisms from CAP and SCEDC are similar and, based on the 3D synthetics fits to data, are clearly not correct. I assigned the focal mechanism of 9722633, a well-fit earthquake that occurred in the same region less than one year earlier. Using the new mechanism for 9817605, I produced 3D synthetics with measurements at 112 stations, indicating a very well-recorded earthquake. None of the CHT events were used in the tomographic inversion, and they await SEM-based inversion (*Liu et al.*, 2004) using the final model ($\mathbf{m}_{16}$).

Additional labels are associated with the focal mechanisms in each column:

- For the CAP focal mechanisms, we list the depth and also the magnitude.
- For the JH focal mechanism, "A: P29, R4" would denote quality A, 29 P-wave polarities used, and 4 S/P amplitude ratios used.
- For the SCEDC focal mechanisms, the variance reduction is listed. The variance reduction determines the "quality factor" as follows:

VR interval	quality factor
$VR > 60$	A : "Mw, MT good enough for distribution"
$40 < VR < 60$	B : "Mw only good enough for distribution"
$VR < 40$	C : "Solution needs review before distribution"

- For the SEMm00 focal mechanisms, we list the percent non-double couple, which can range from 0 to 100.
- For the SEMm12 focal mechanisms, we list the depth and also the magnitude.

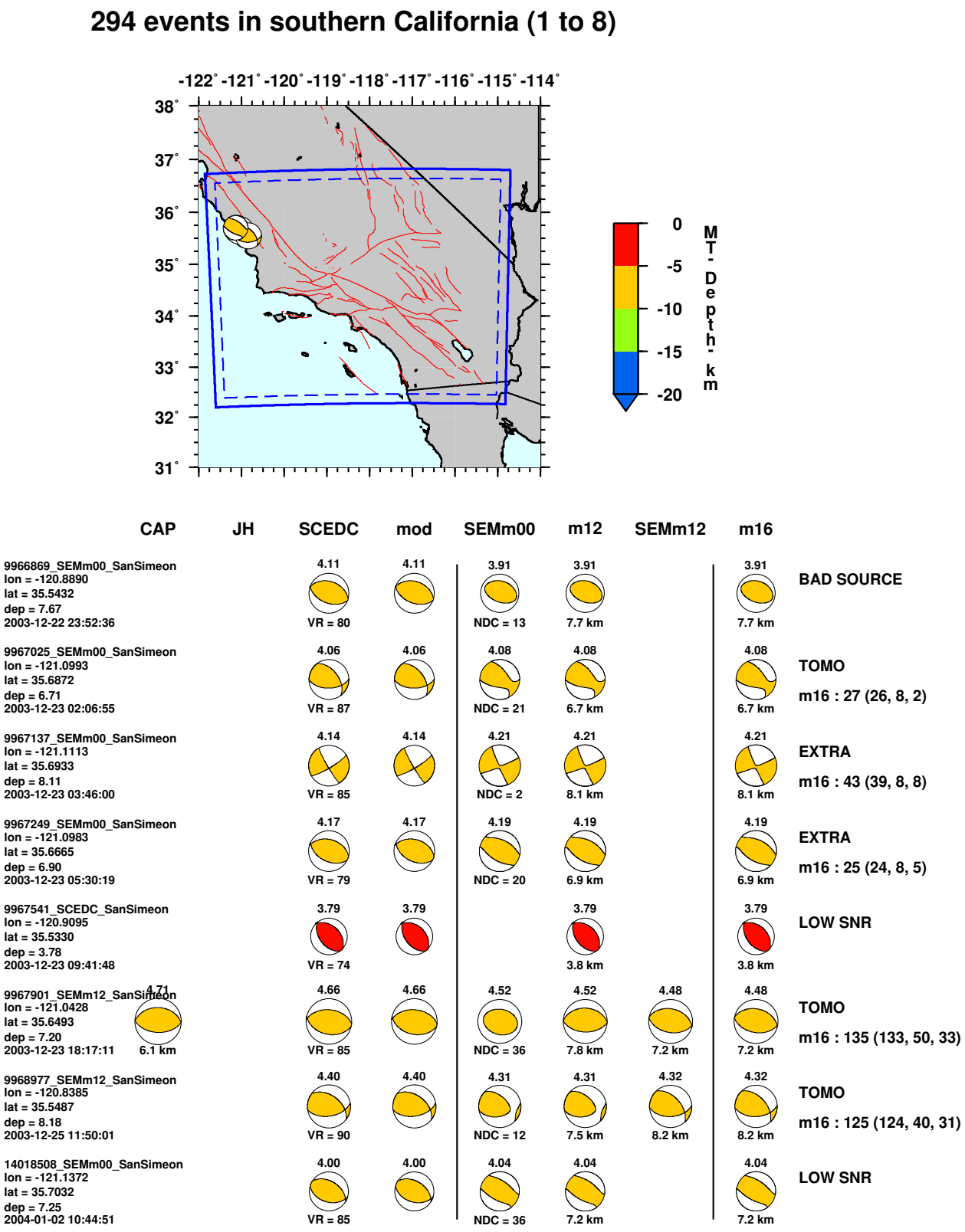

Figure D.1: Source mechanisms considered in the southern California tomography study (1 through 8 out of 294).

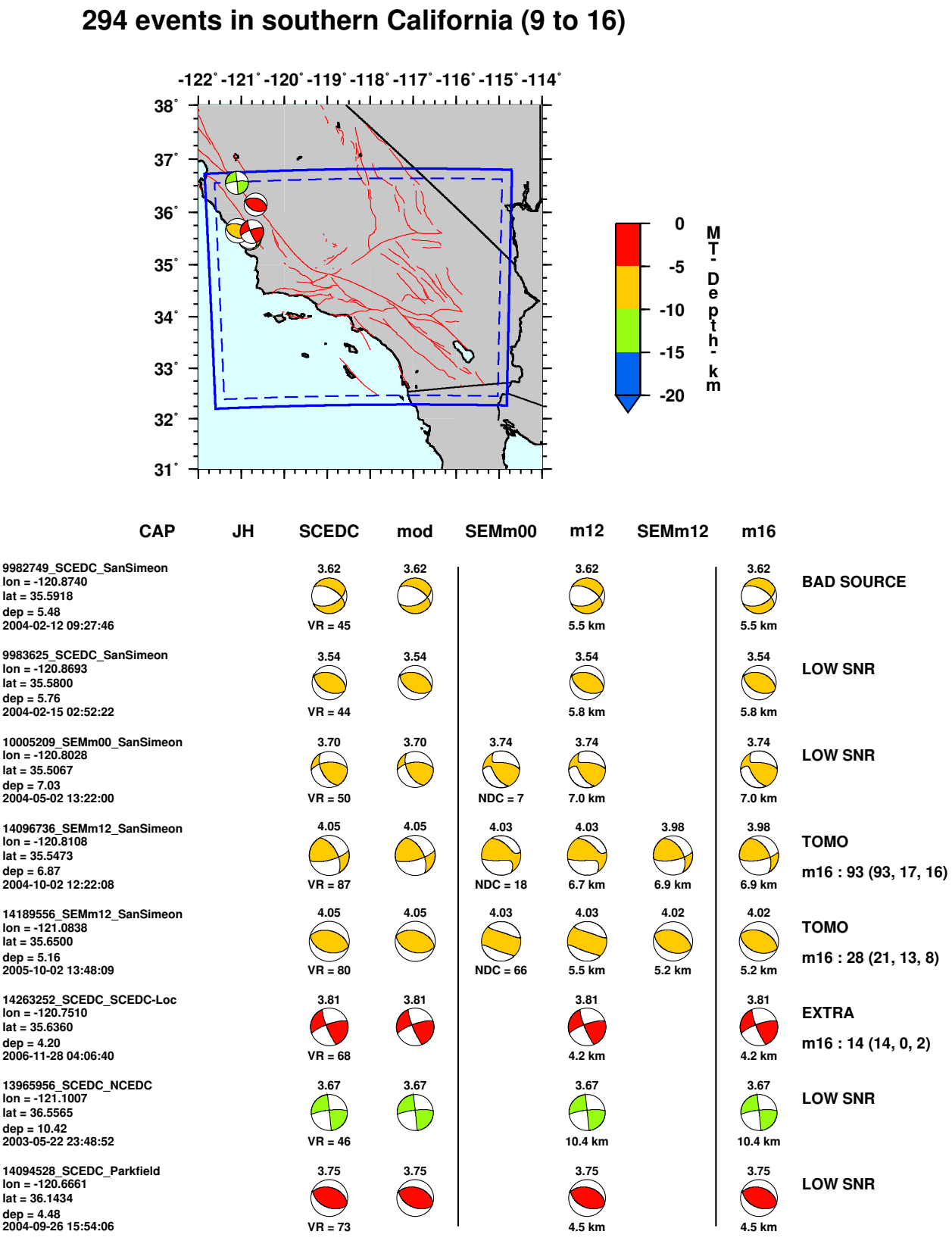

Figure D.2: Source mechanisms considered in the southern California tomography study (9 through 16 out of 294).

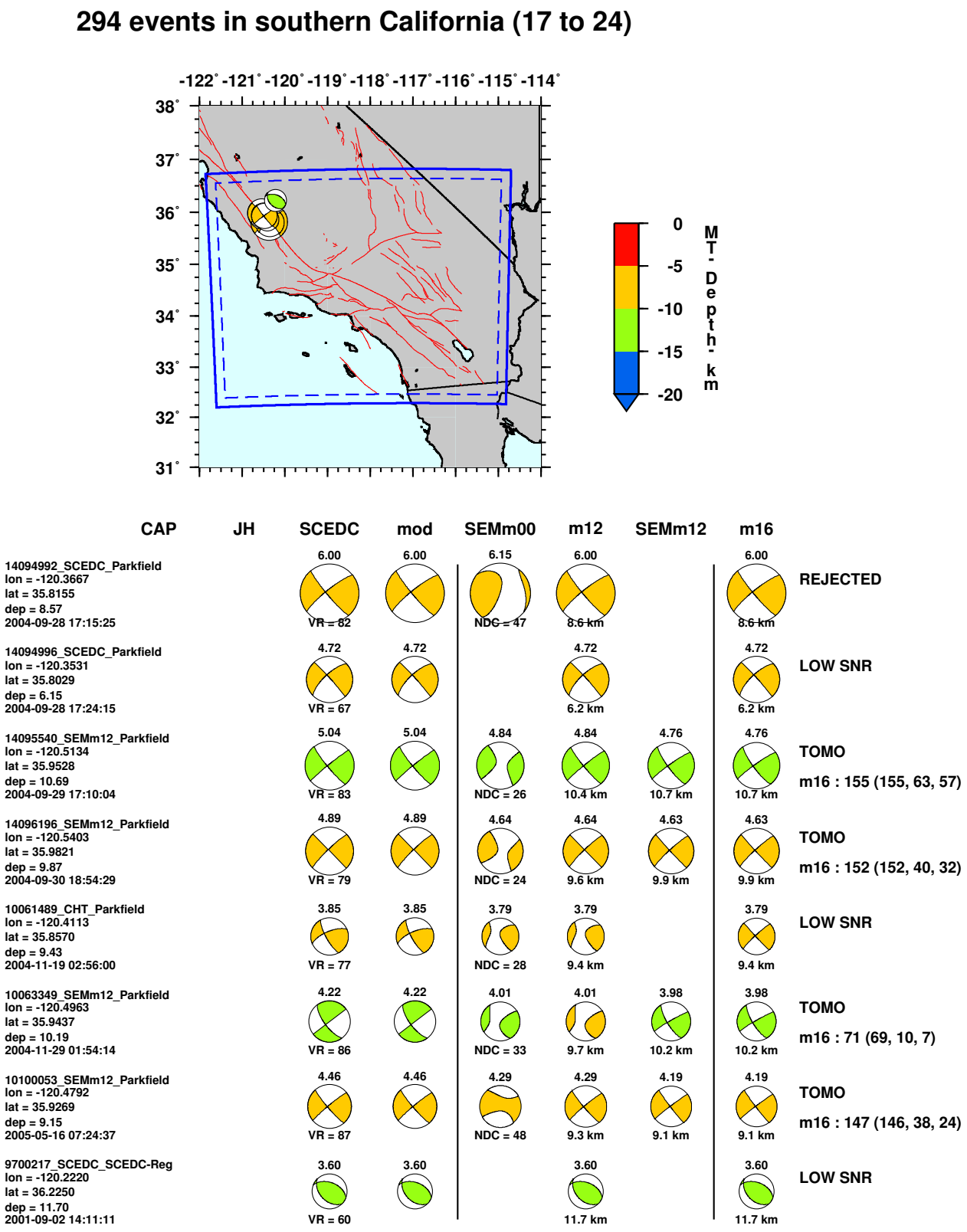

Figure D.3: Source mechanisms considered in the southern California tomography study (17 through 24 out of 294).

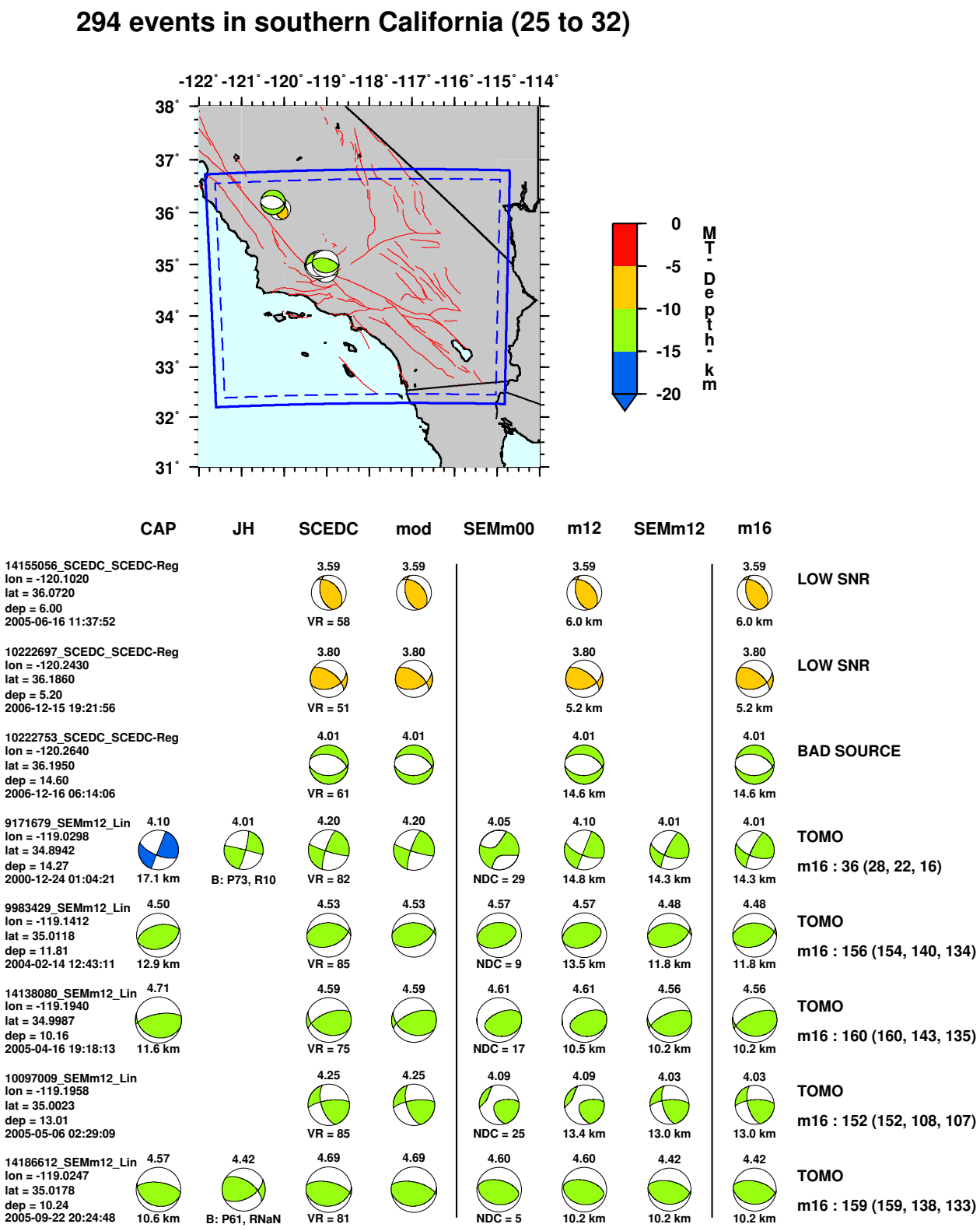

Figure D.4: Source mechanisms considered in the southern California tomography study (25 through 32 out of 294).

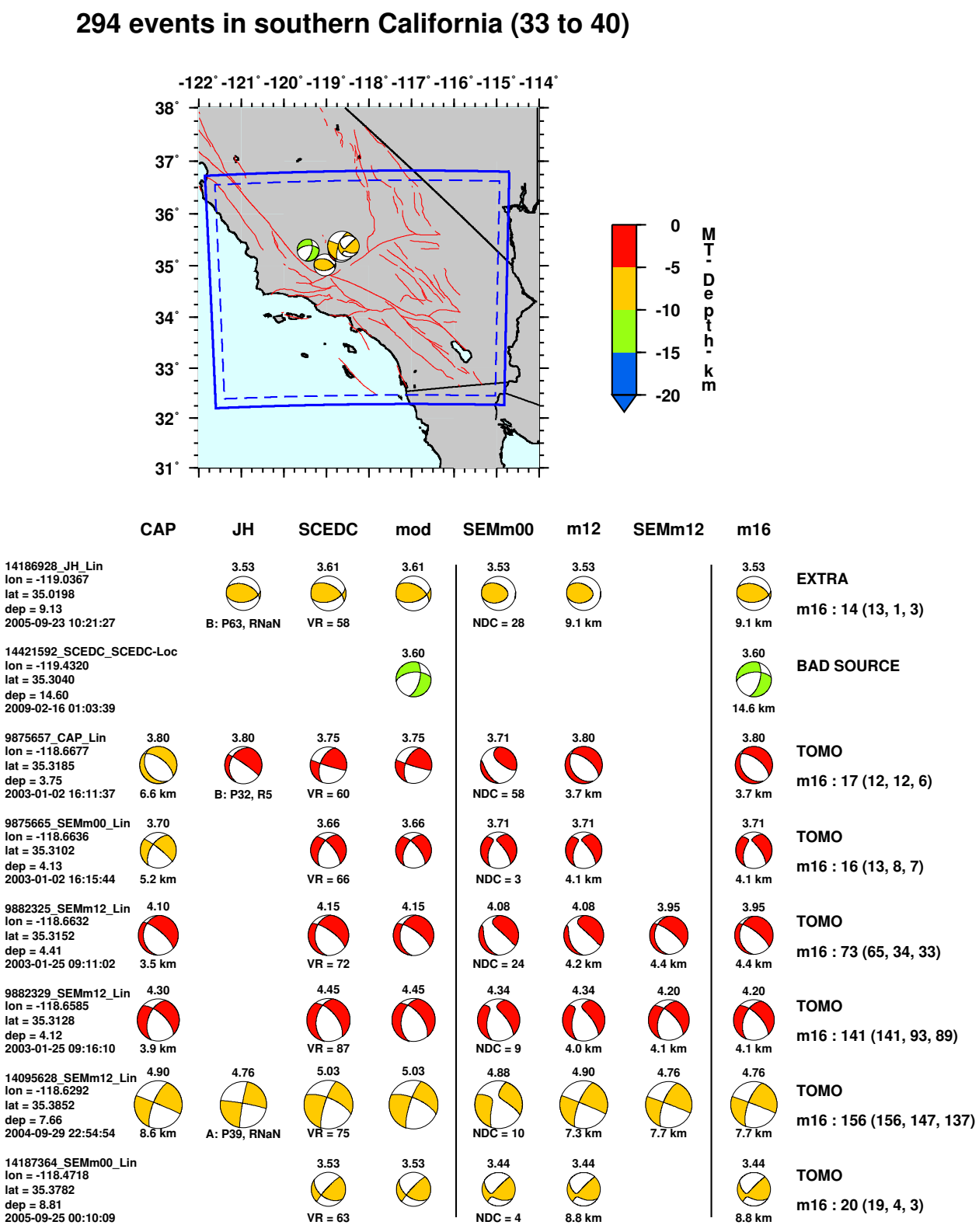

Figure D.5: Source mechanisms considered in the southern California tomography study (33 through 40 out of 294).

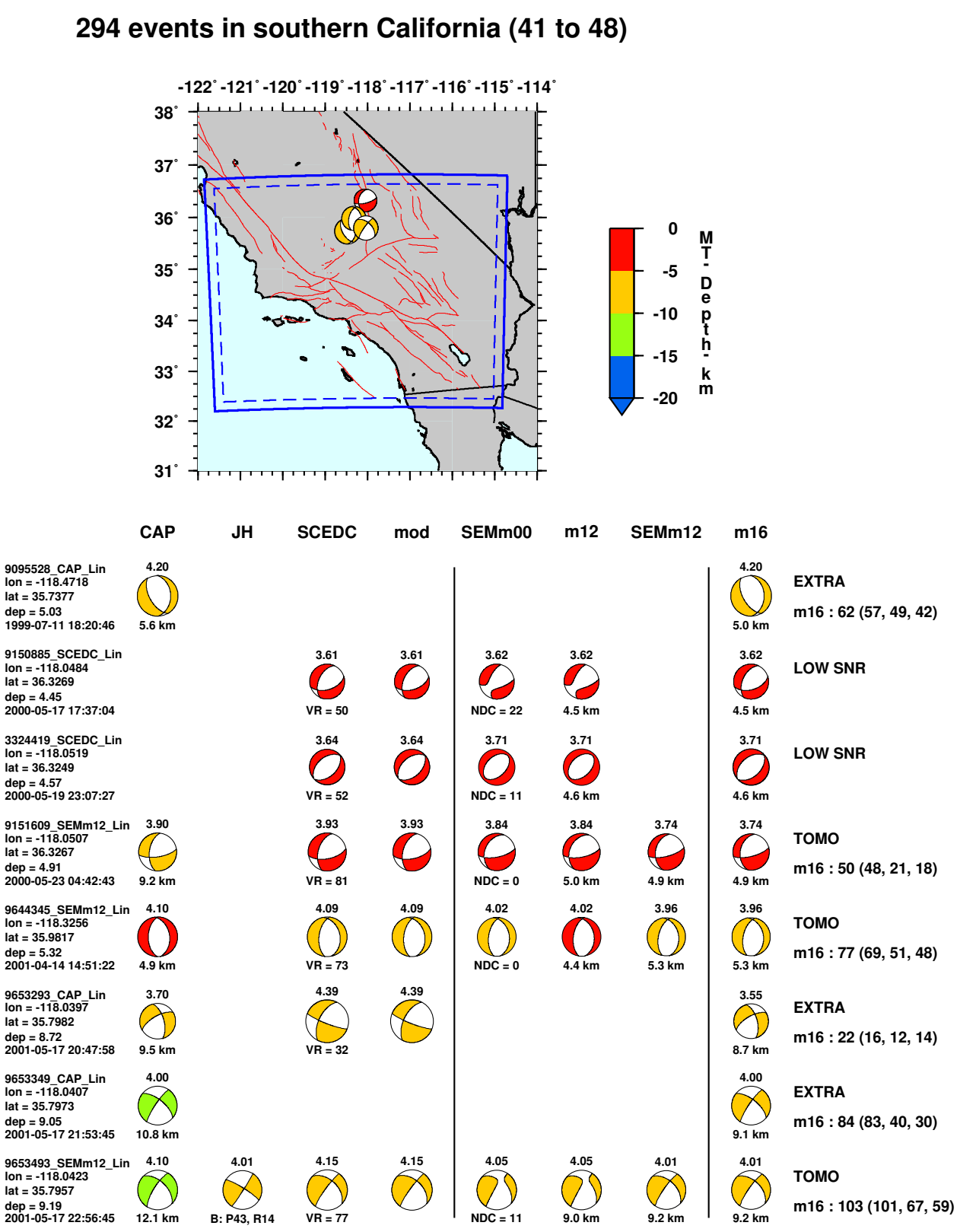

Figure D.6: Source mechanisms considered in the southern California tomography study (41 through 48 out of 294).

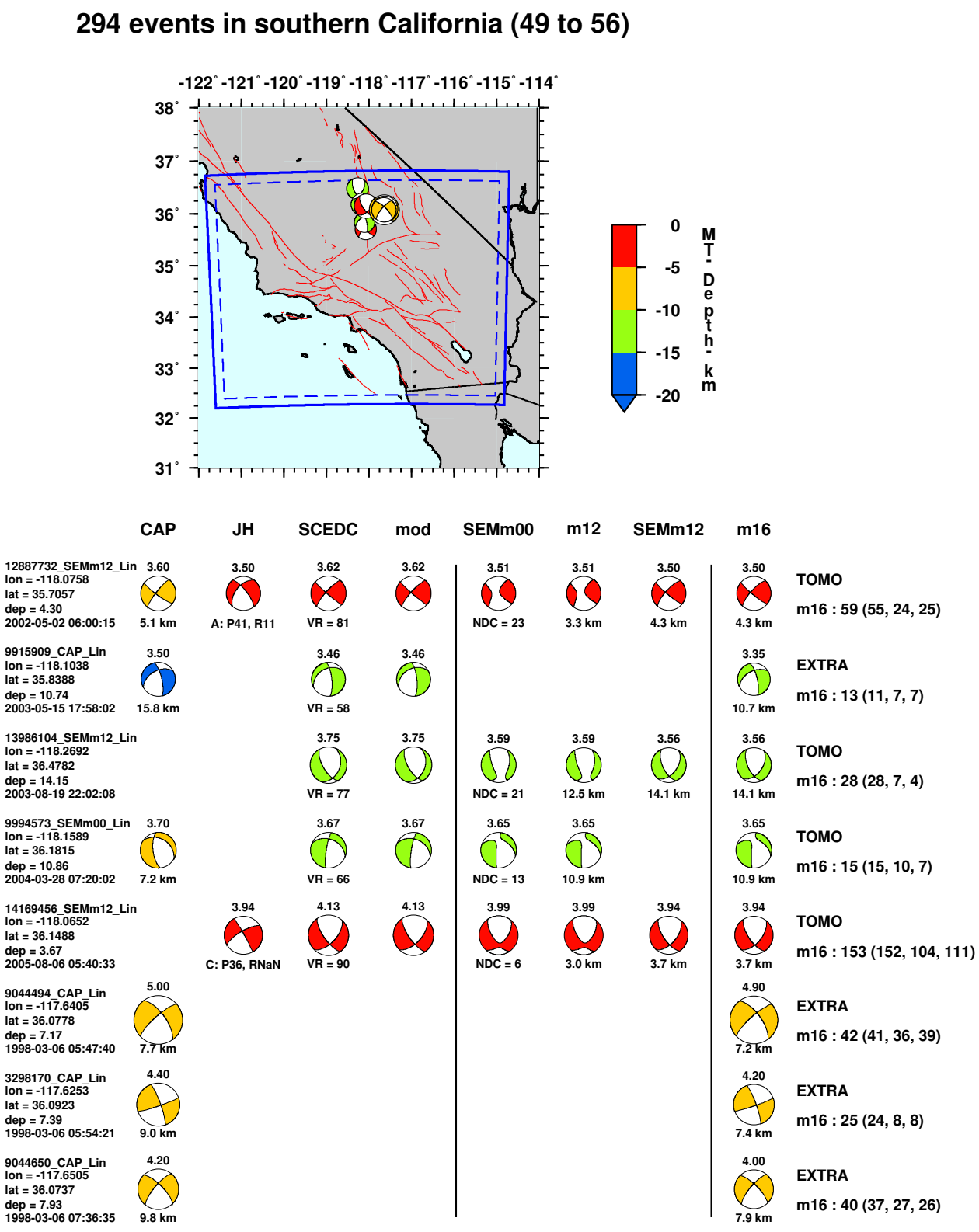

Figure D.7: Source mechanisms considered in the southern California tomography study (49 through 56 out of 294).

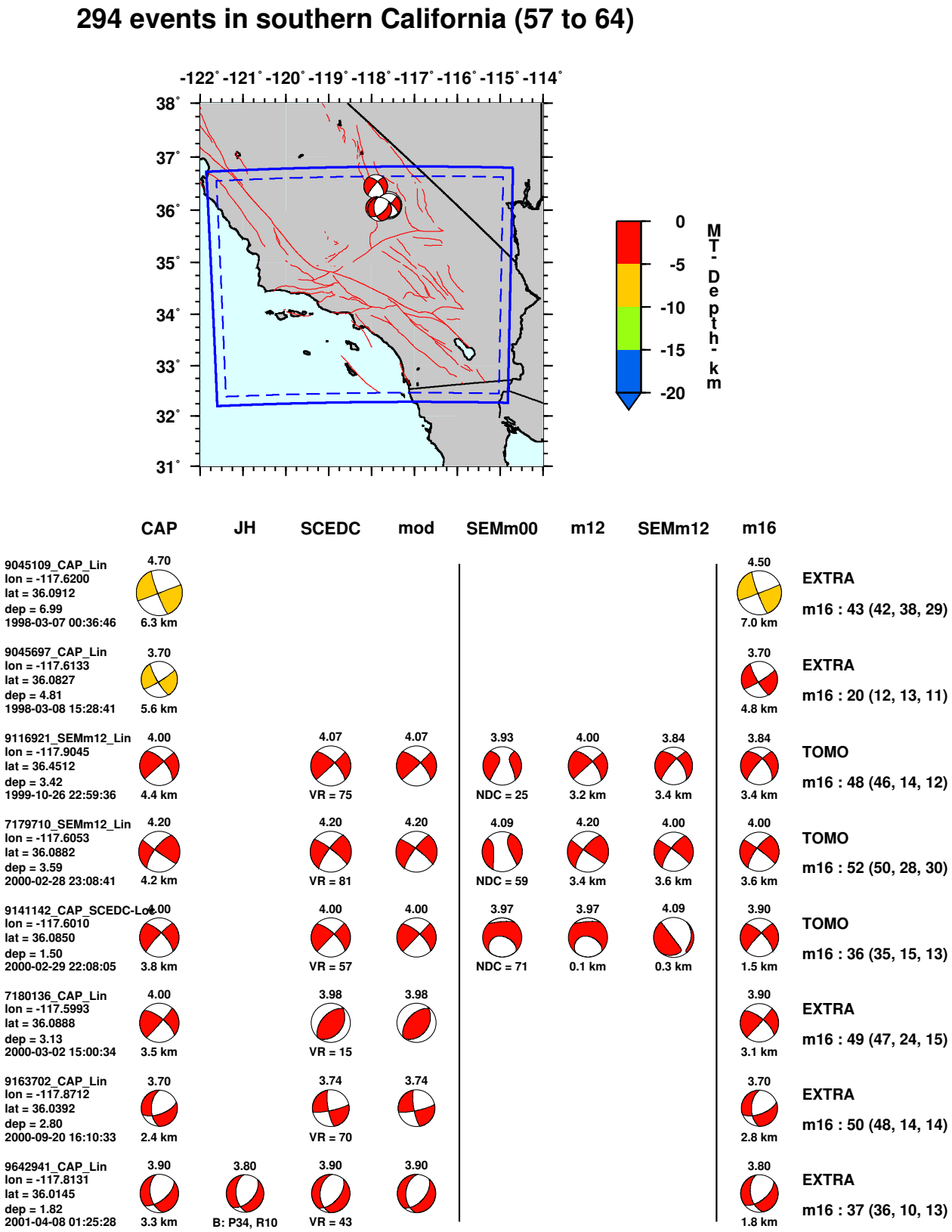

Figure D.8: Source mechanisms considered in the southern California tomography study (57 through 64 out of 294).

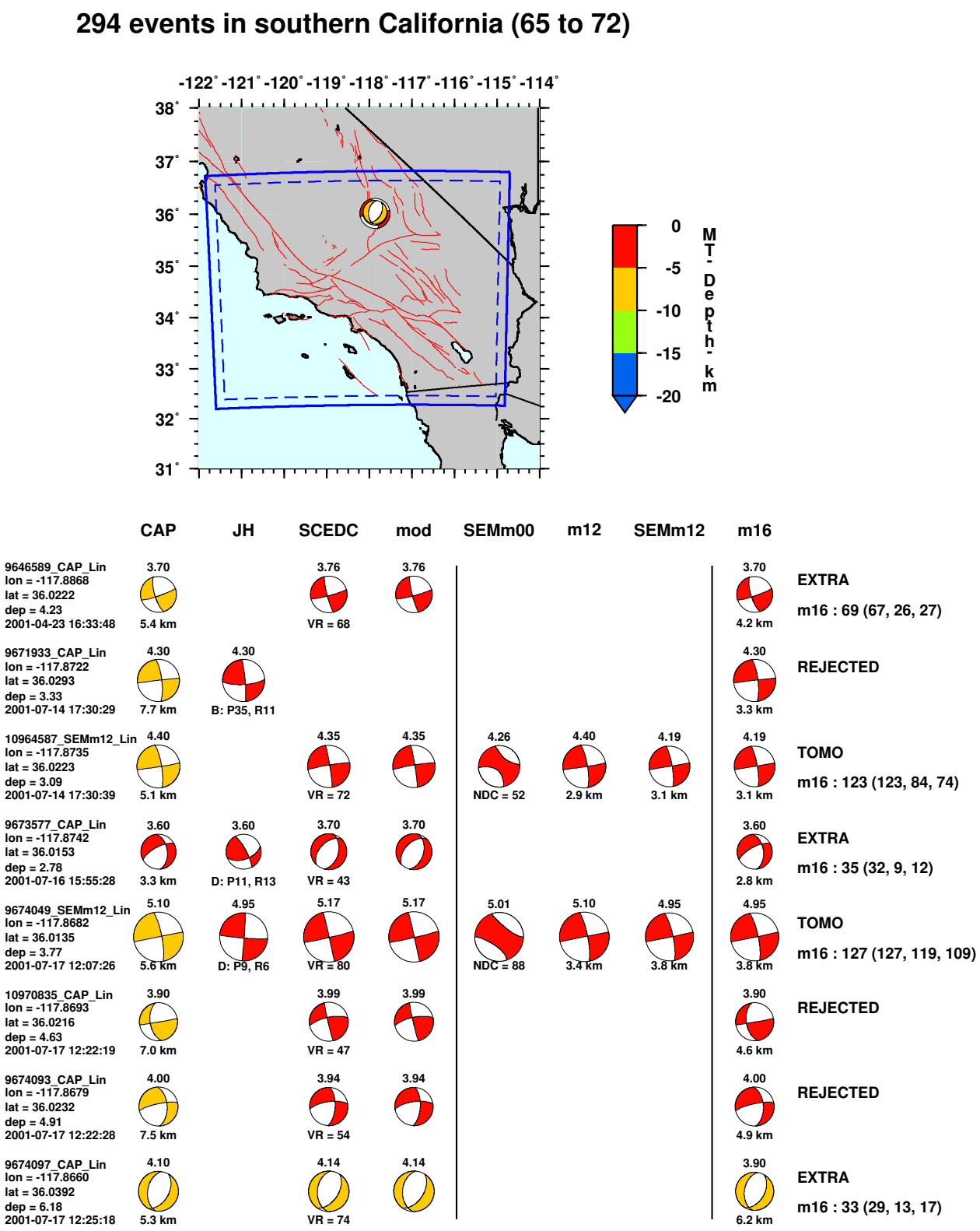

Figure D.9: Source mechanisms considered in the southern California tomography study (65 through 72 out of 294).

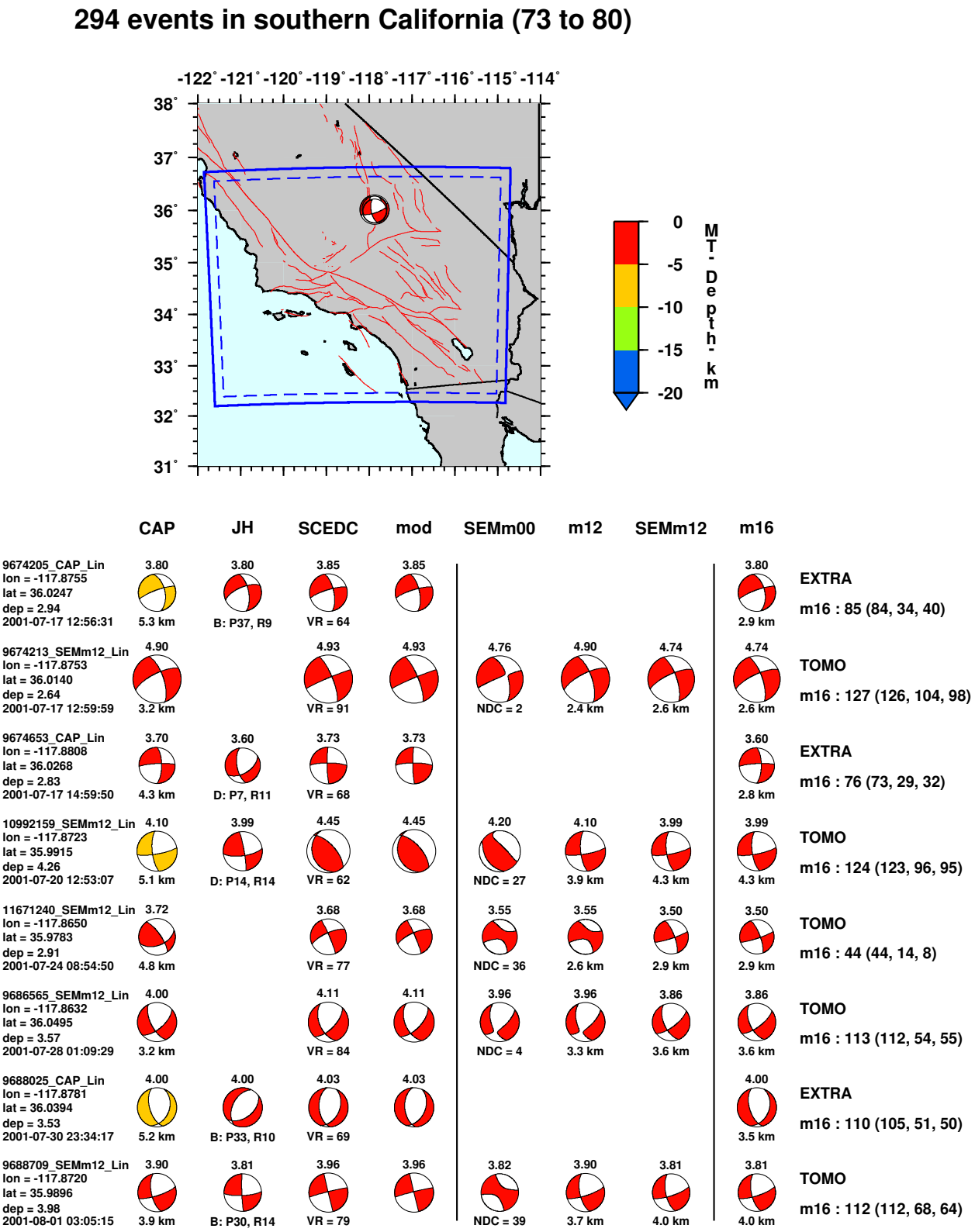

Figure D.10: Source mechanisms considered in the southern California tomography study (73 through 80 out of 294).

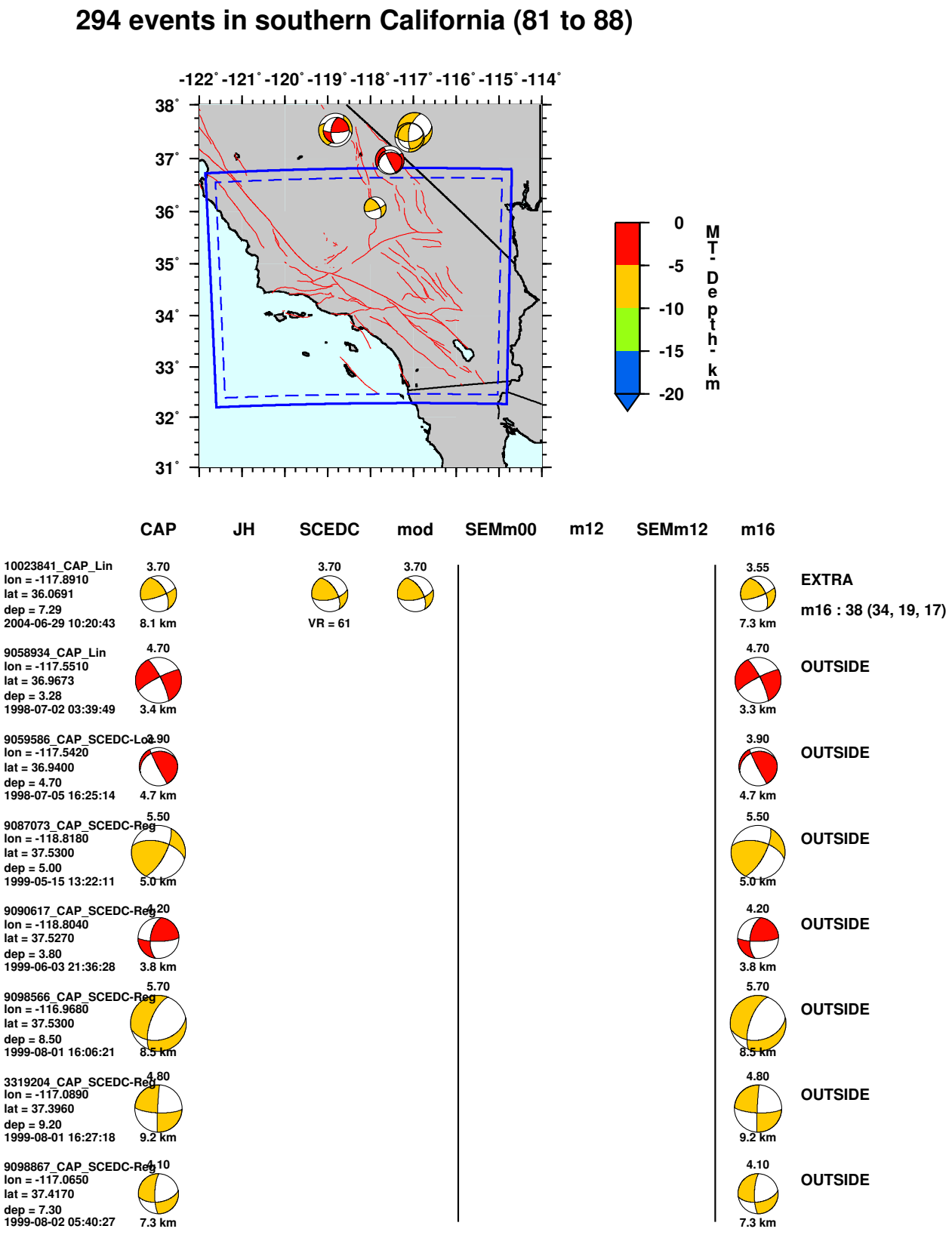

Figure D.11: Source mechanisms considered in the southern California tomography study (81 through 88 out of 294).

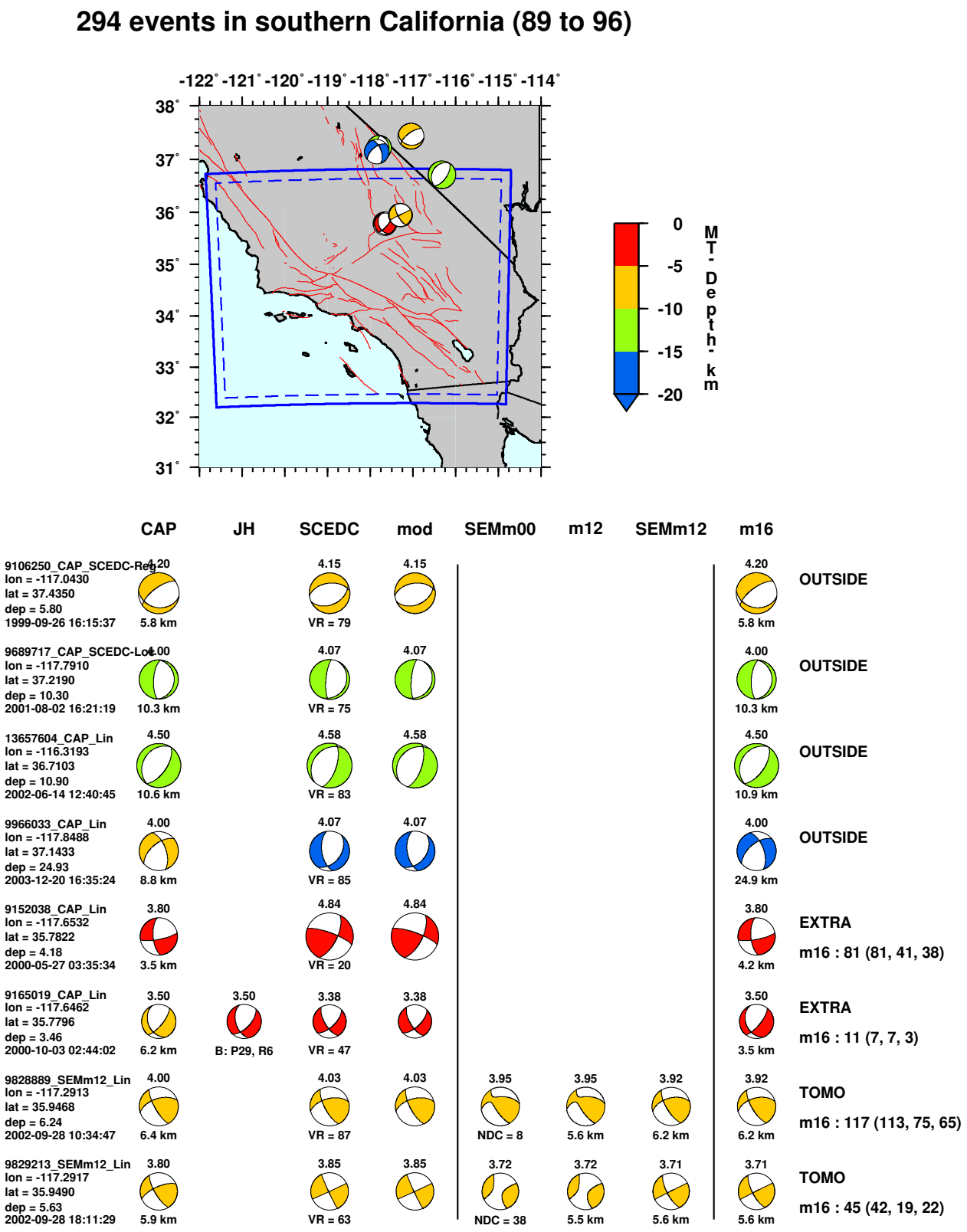

Figure D.12: Source mechanisms considered in the southern California tomography study (89 through 96 out of 294).

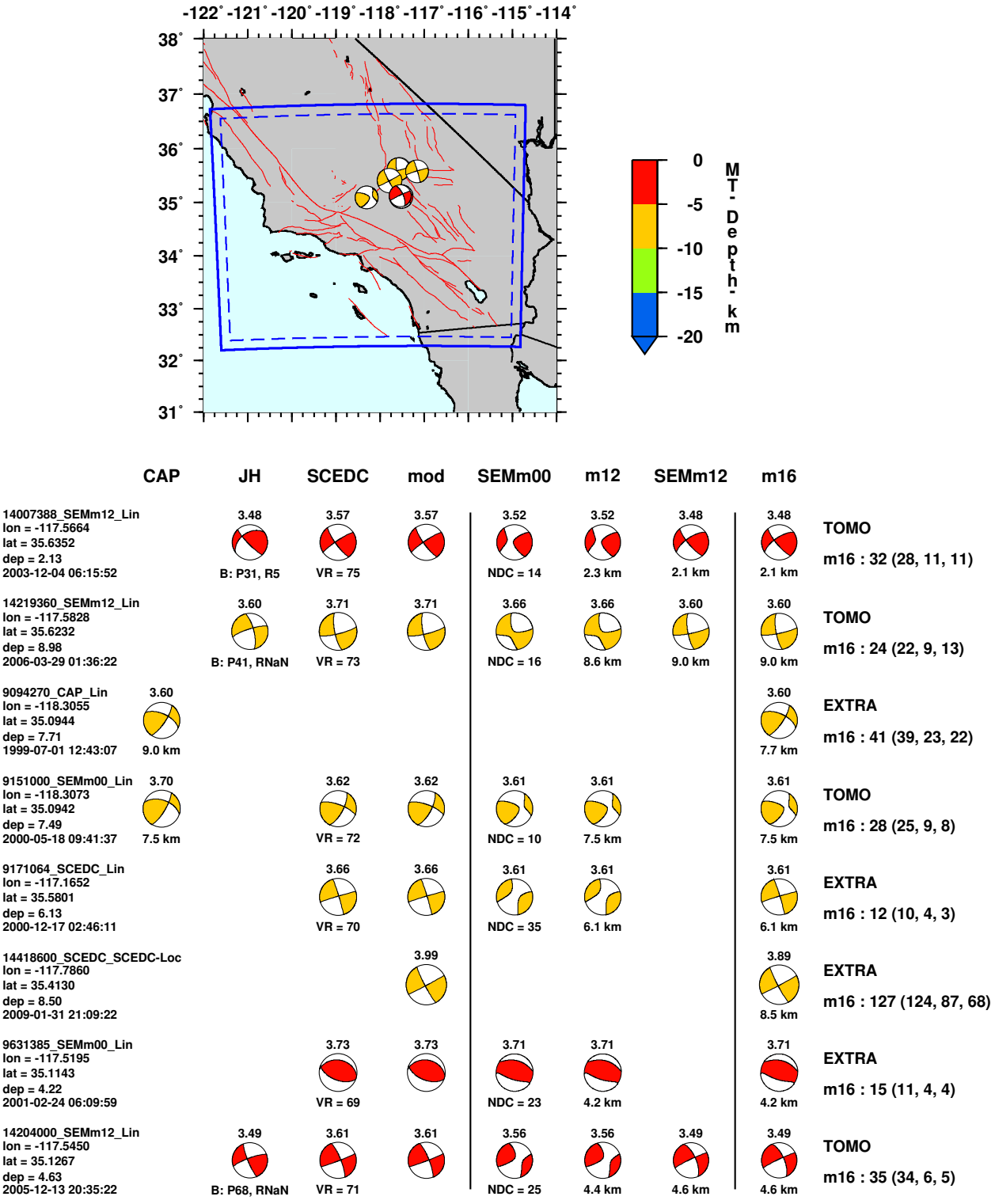

Figure D.13: Source mechanisms considered in the southern California tomography study (97 through 104 out of 294).

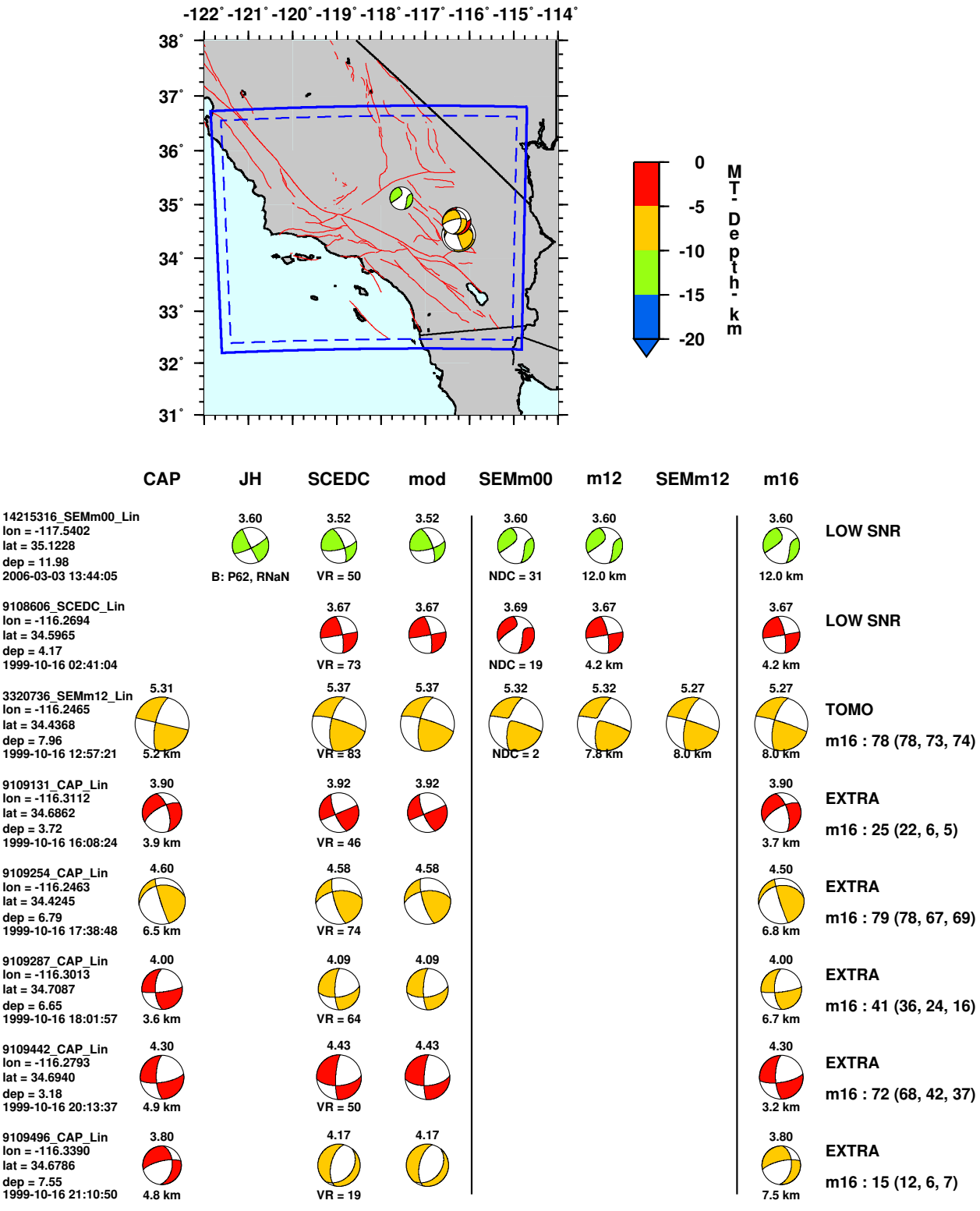

Figure D.14: Source mechanisms considered in the southern California tomography study (105 through 112 out of 294).

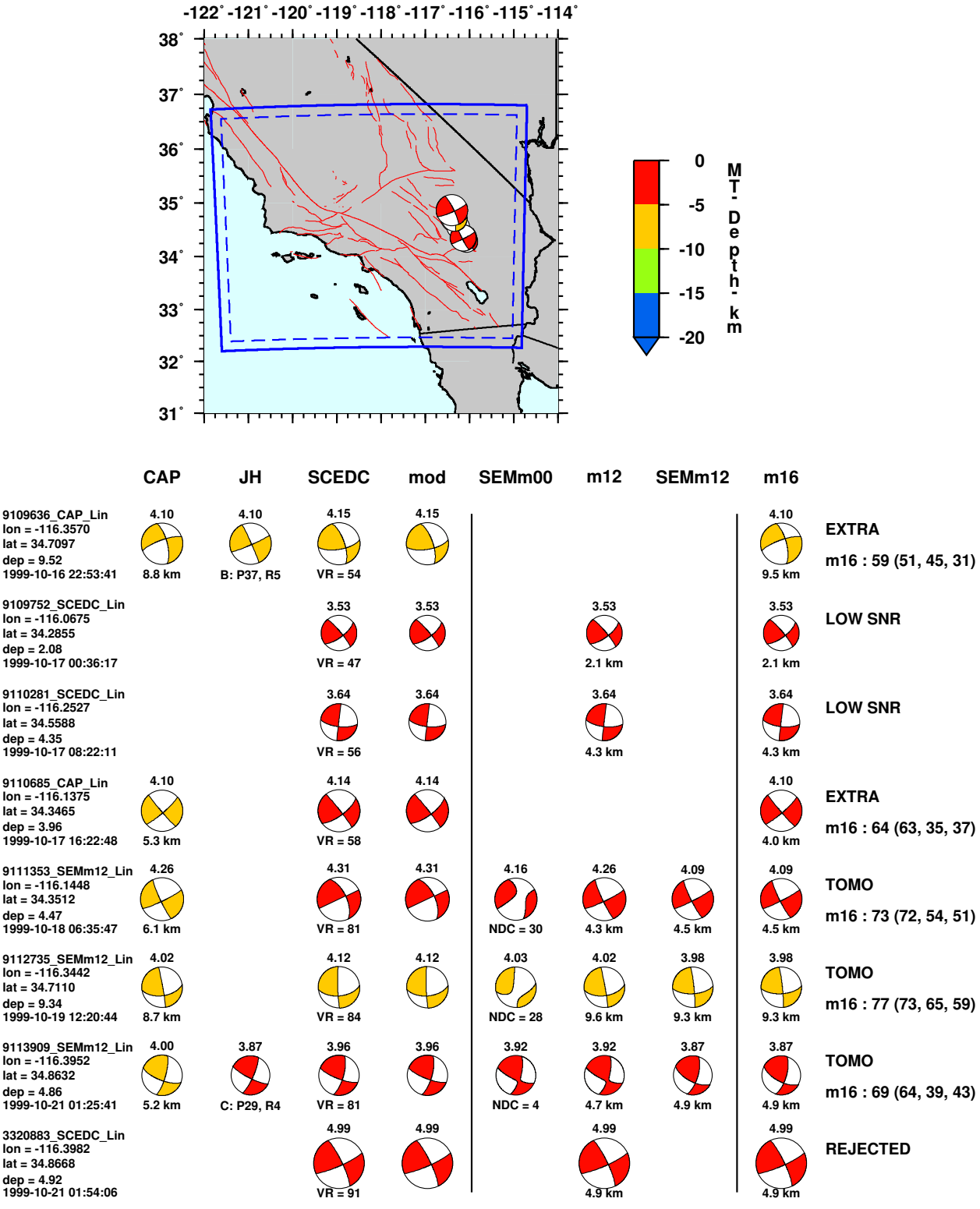

Figure D.15: Source mechanisms considered in the southern California tomography study (113 through 120 out of 294).

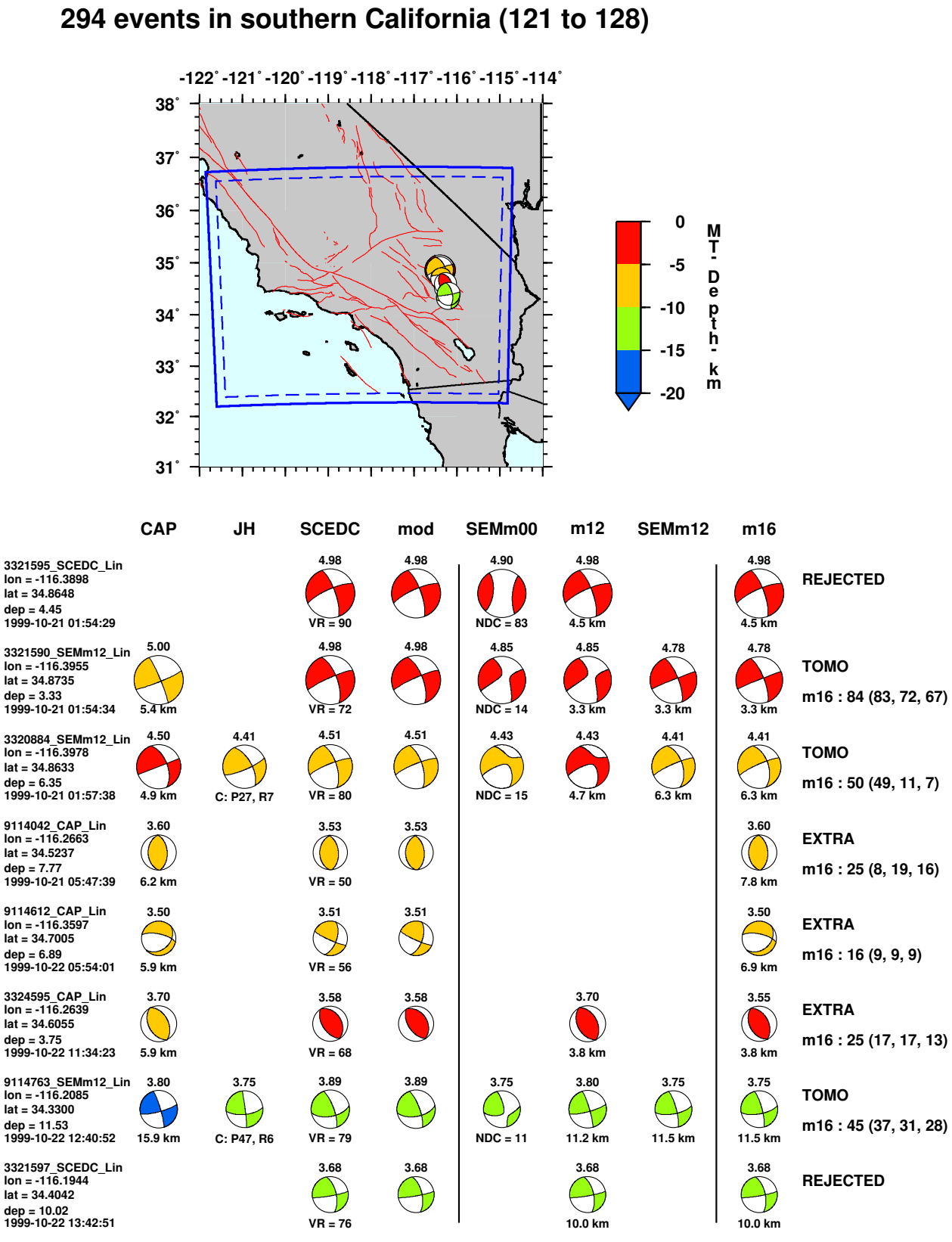

Figure D.16: Source mechanisms considered in the southern California tomography study (121 through 128 out of 294).

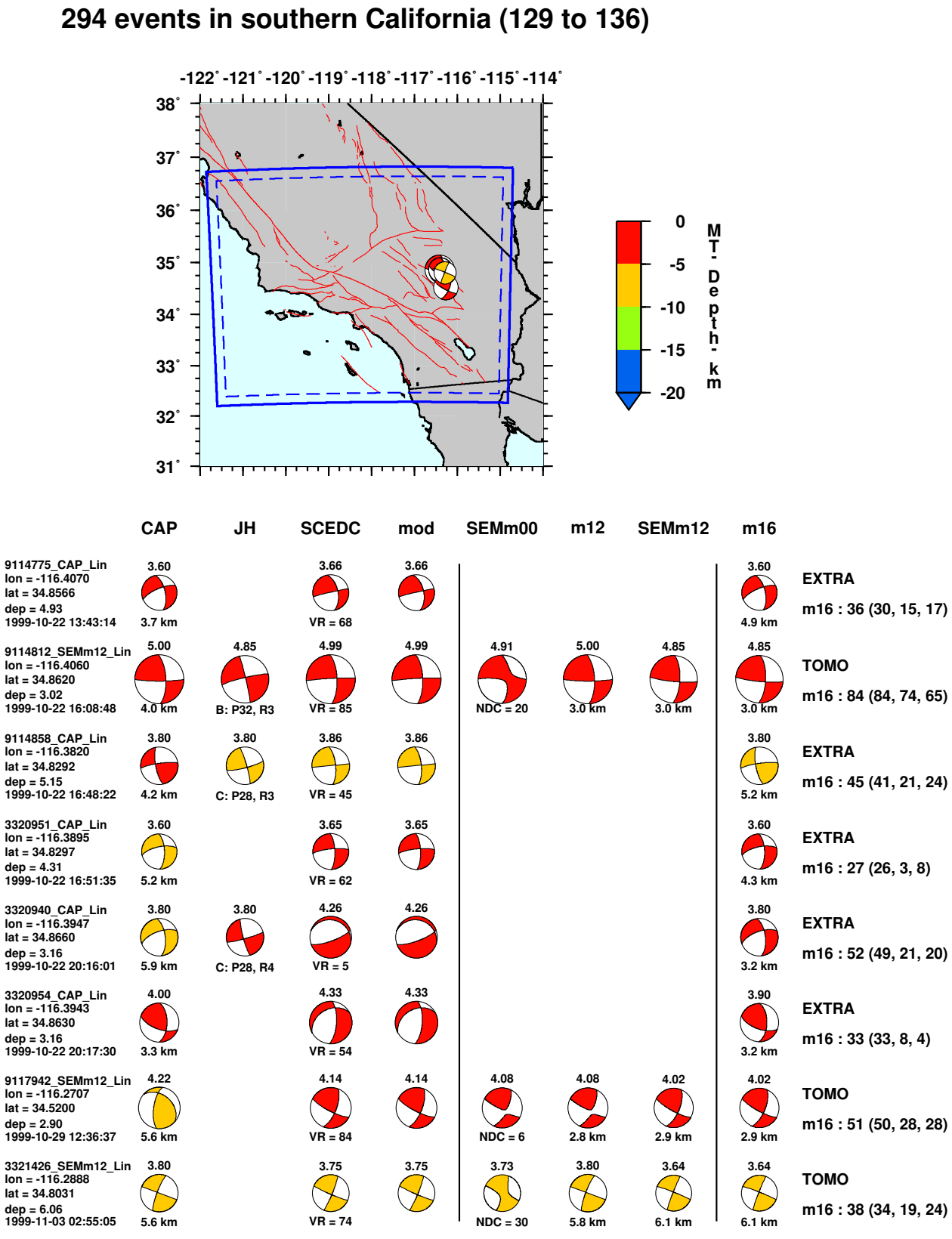

Figure D.17: Source mechanisms considered in the southern California tomography study (129 through 136 out of 294).

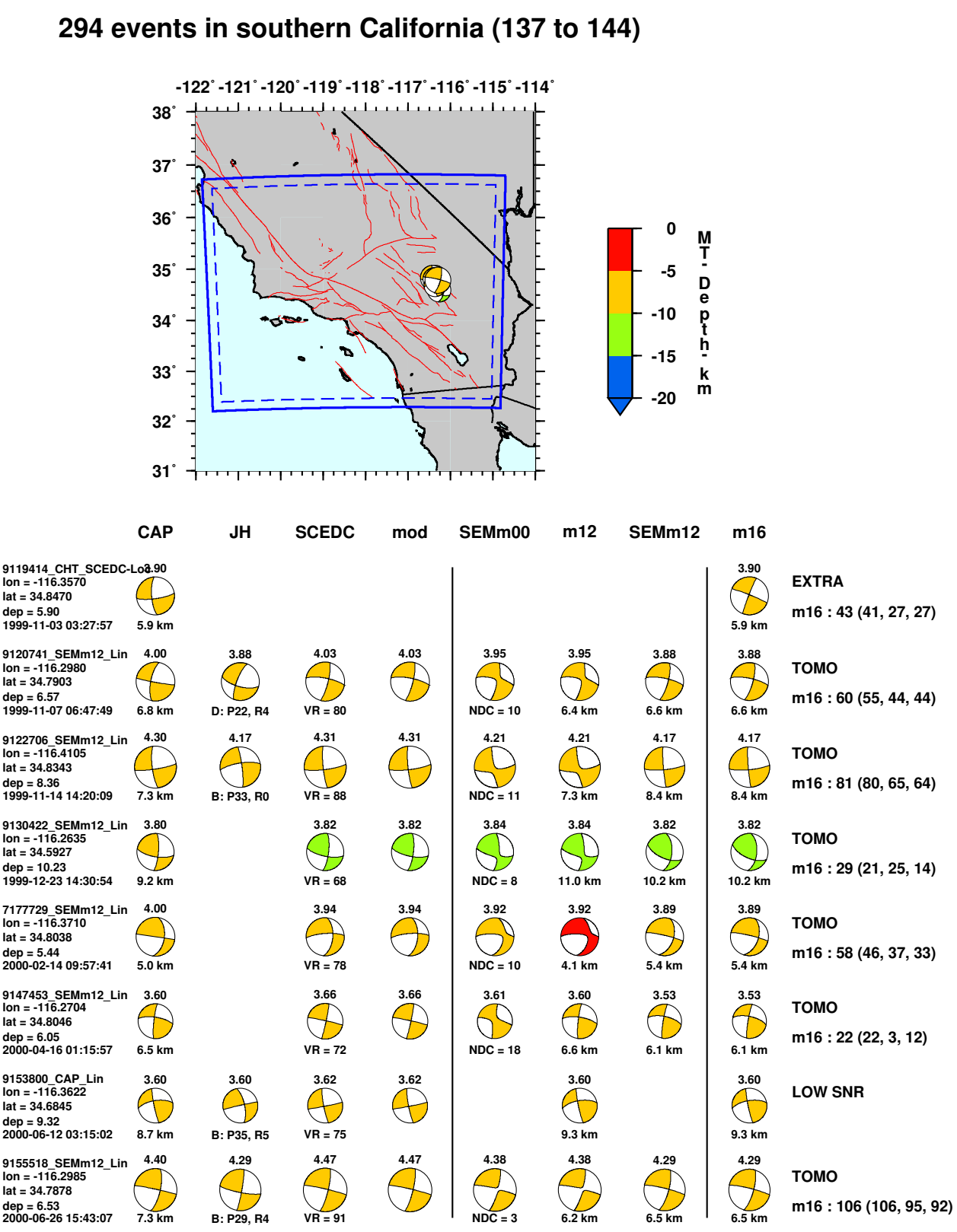

Figure D.18: Source mechanisms considered in the southern California tomography study (137 through 144 out of 294).

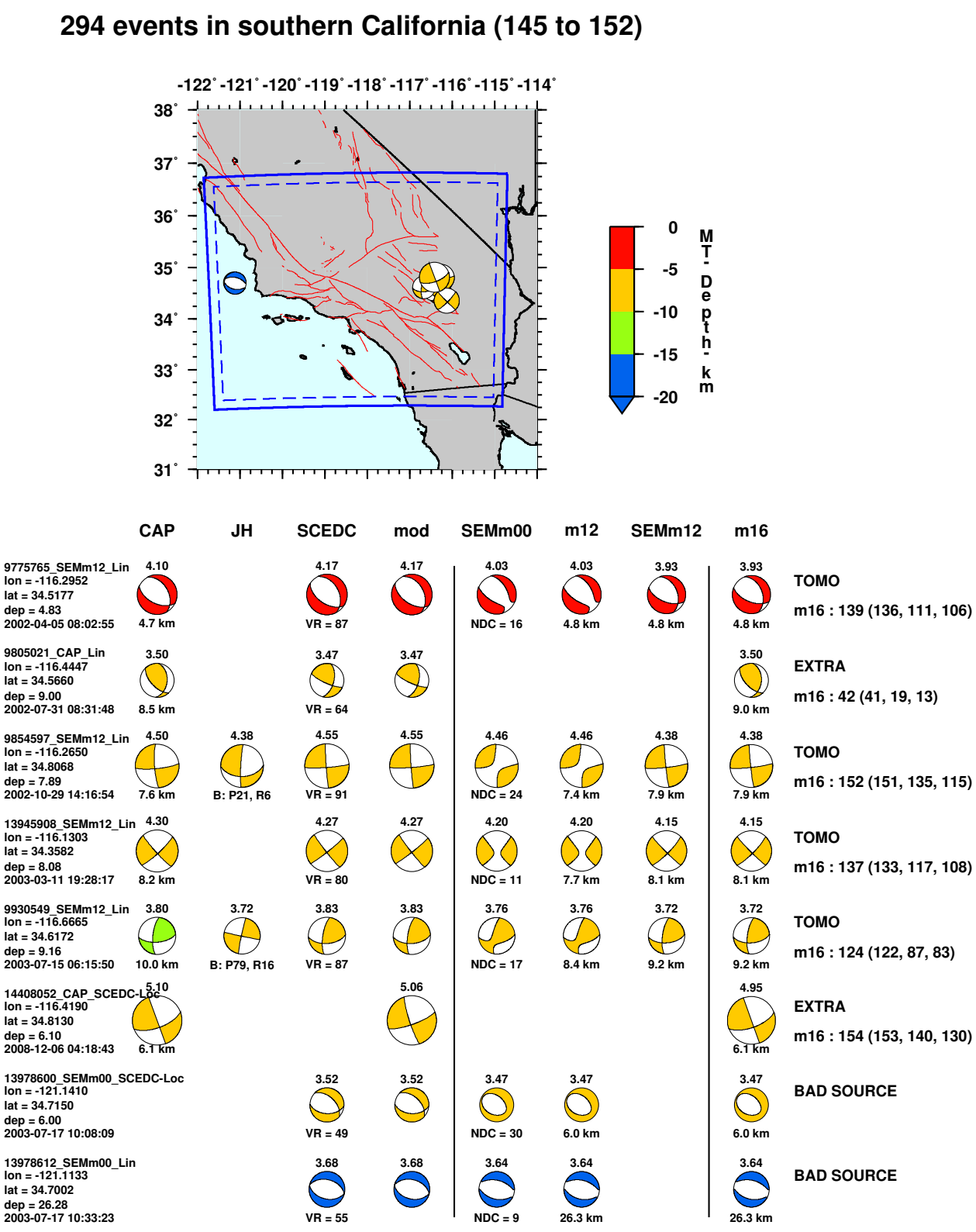

Figure D.19: Source mechanisms considered in the southern California tomography study (145 through 152 out of 294).

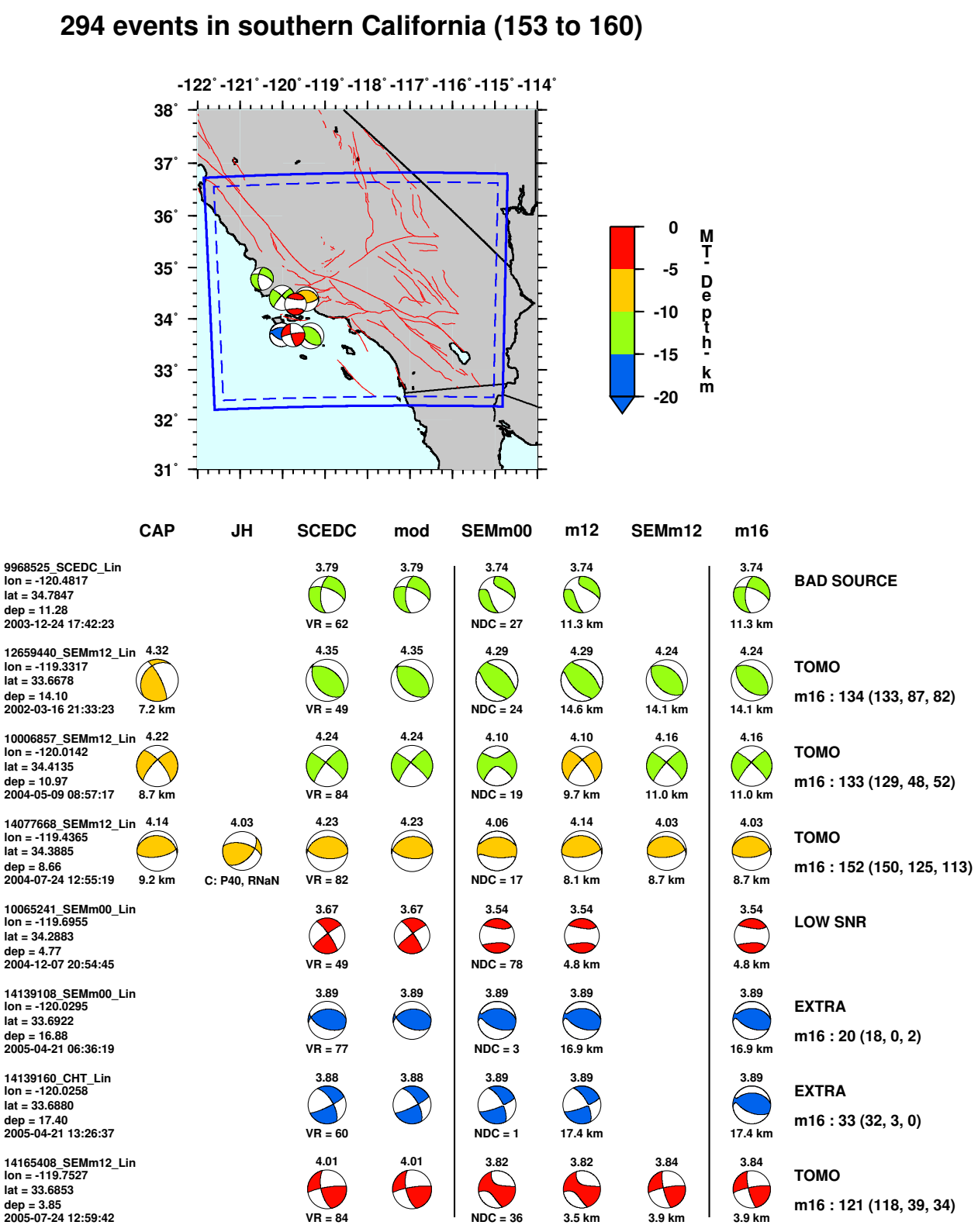

Figure D.20: Source mechanisms considered in the southern California tomography study (153 through 160 out of 294).

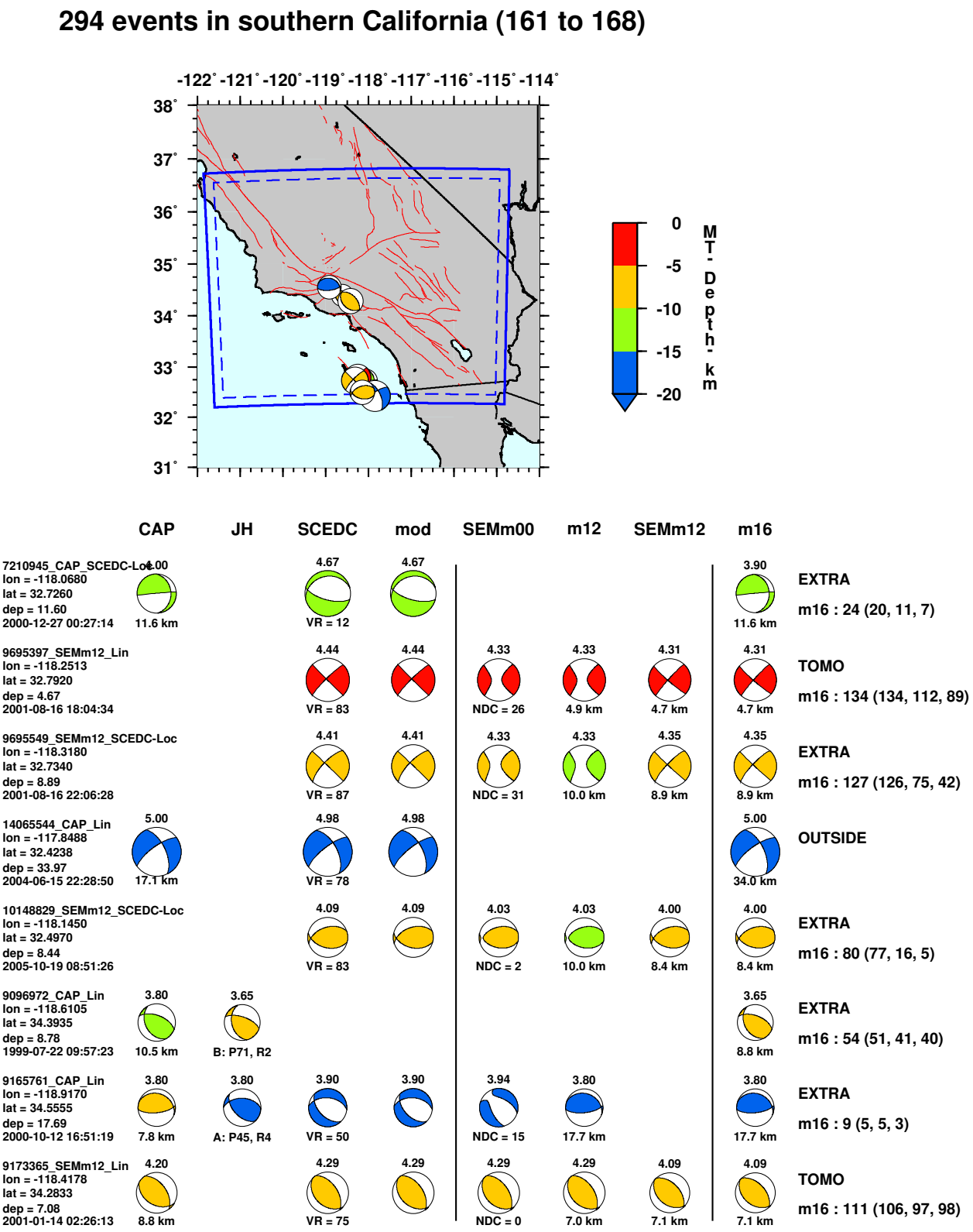

Figure D.21: Source mechanisms considered in the southern California tomography study (161 through 168 out of 294).

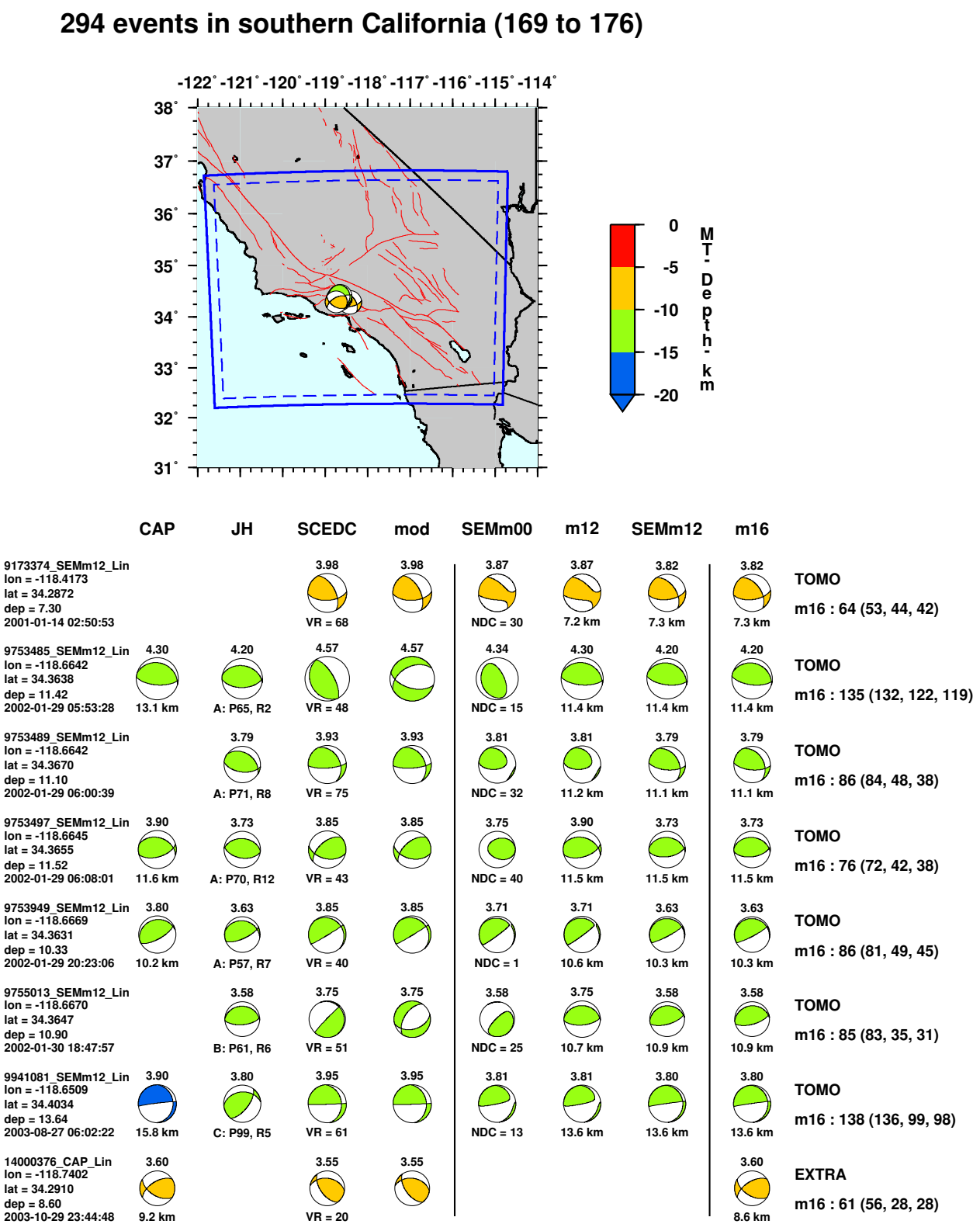

Figure D.22: Source mechanisms considered in the southern California tomography study (169 through 176 out of 294).

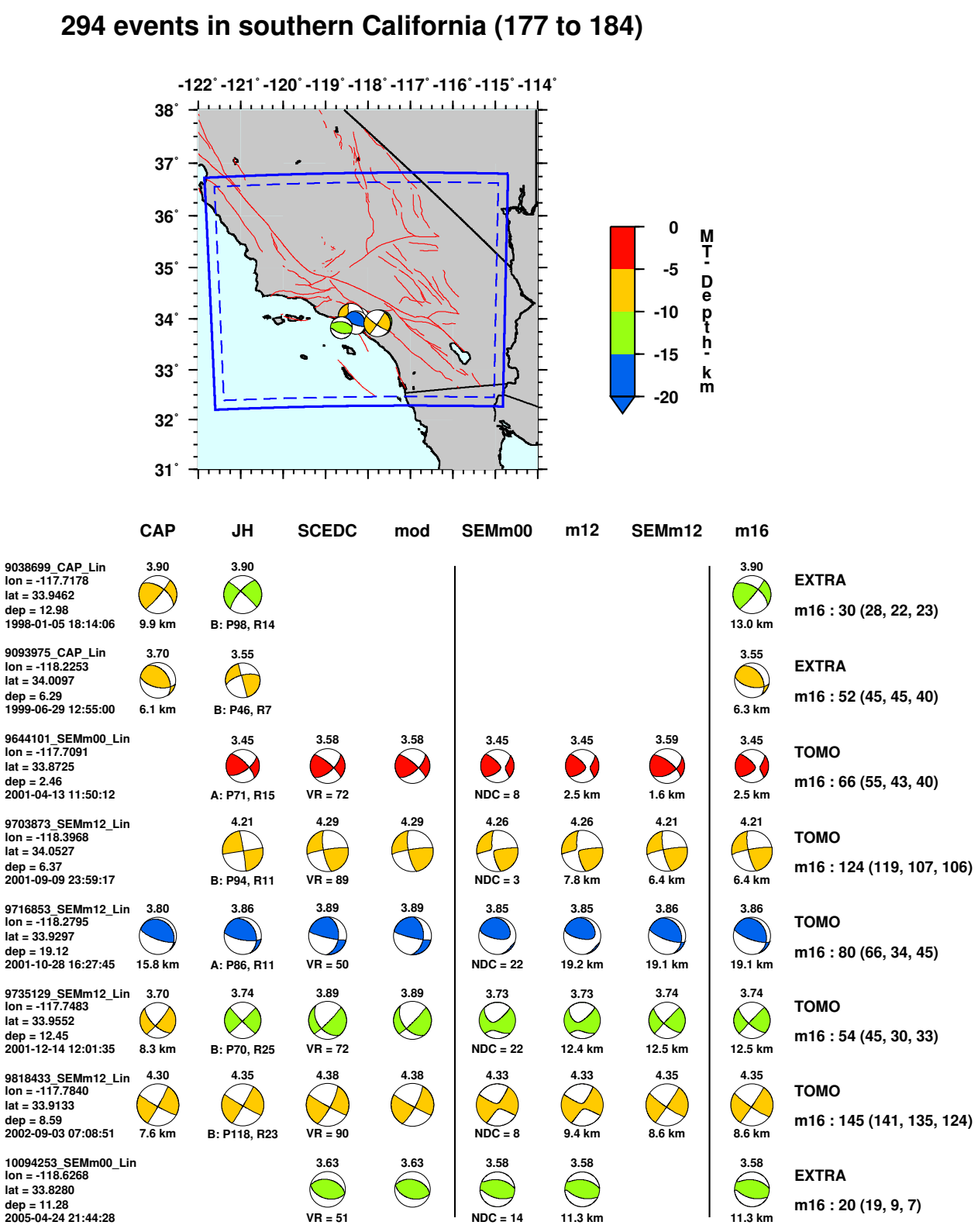

Figure D.23: Source mechanisms considered in the southern California tomography study (177 through 184 out of 294).

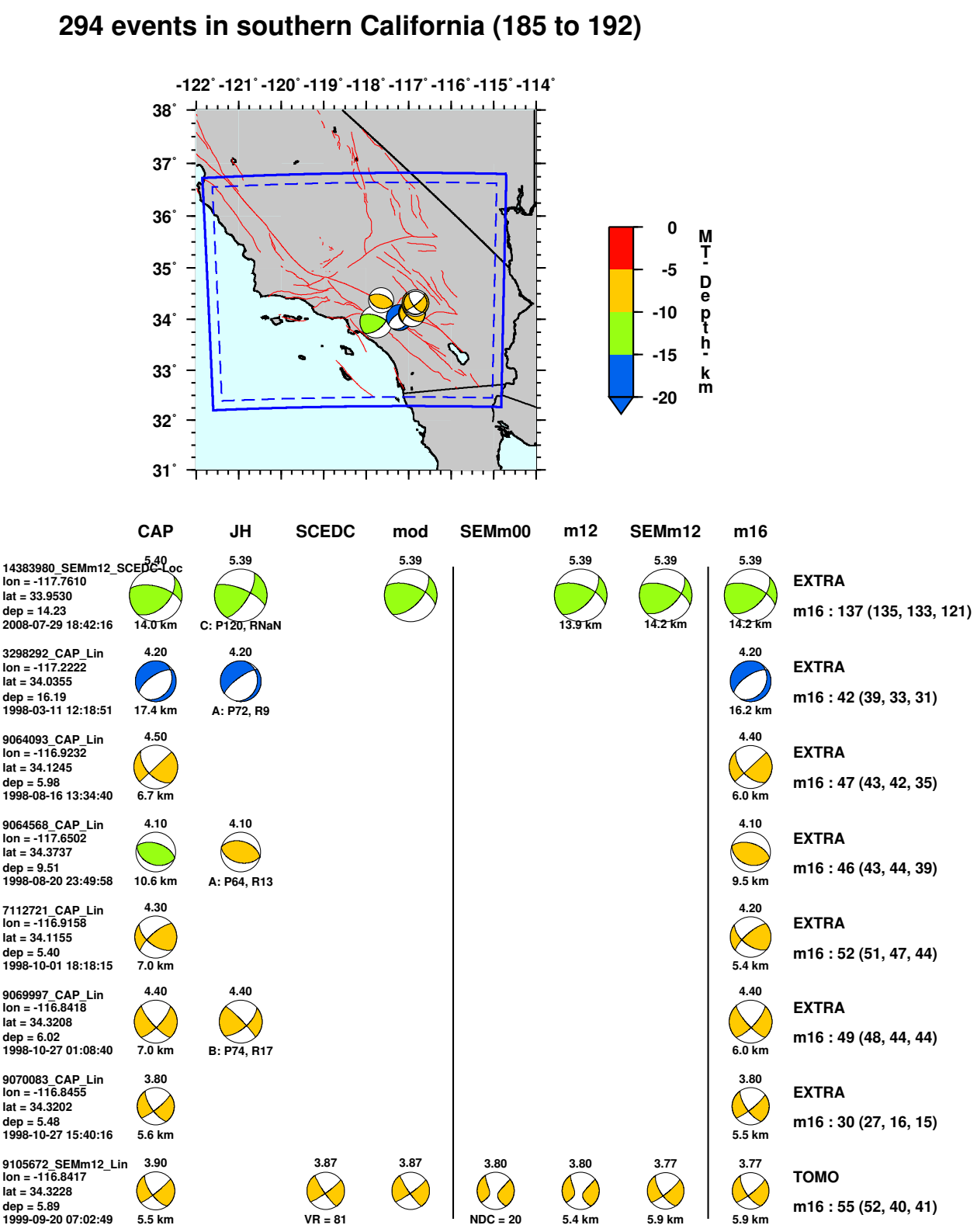

Figure D.24: Source mechanisms considered in the southern California tomography study (185 through 192 out of 294).

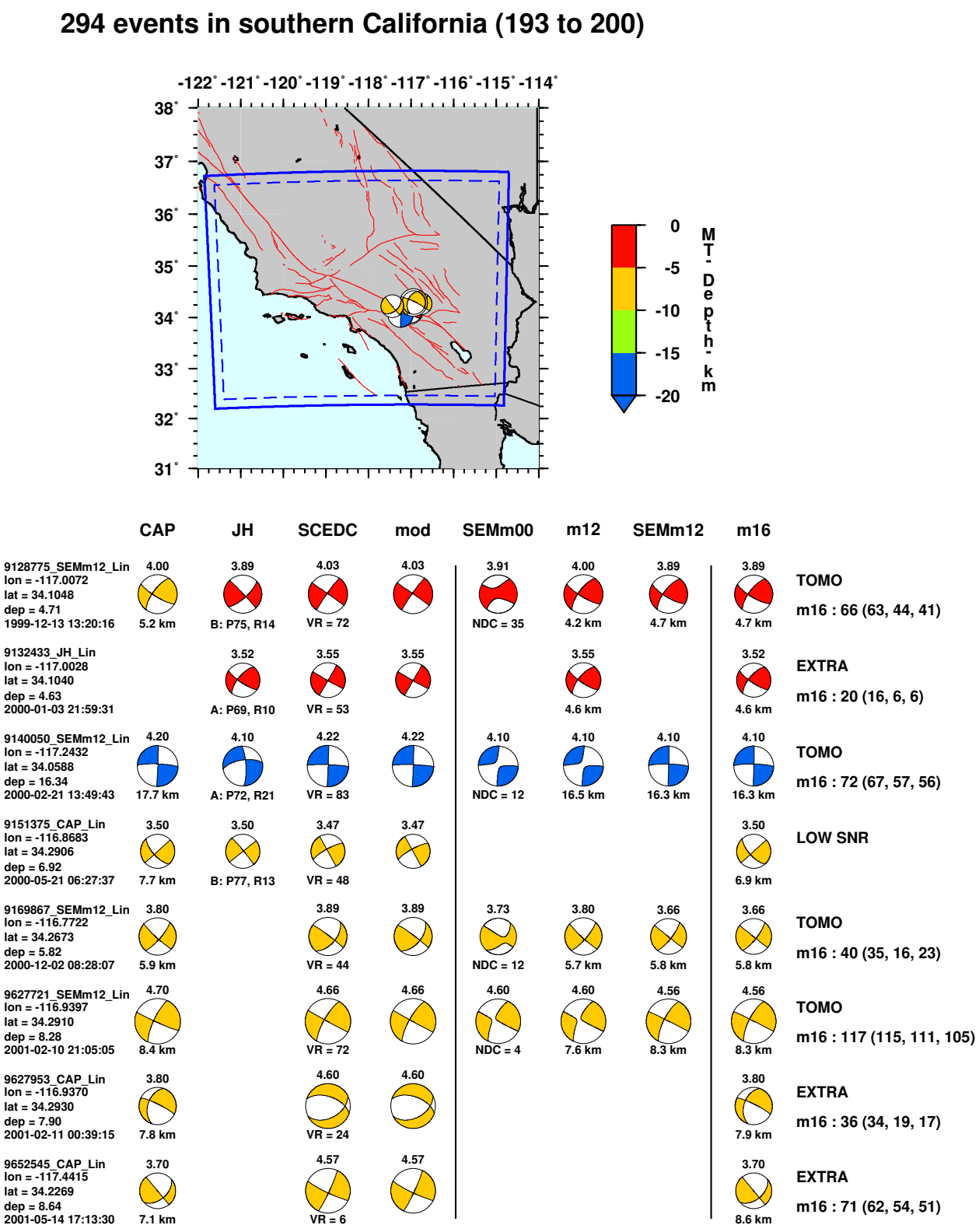

Figure D.25: Source mechanisms considered in the southern California tomography study (193 through 200 out of 294).

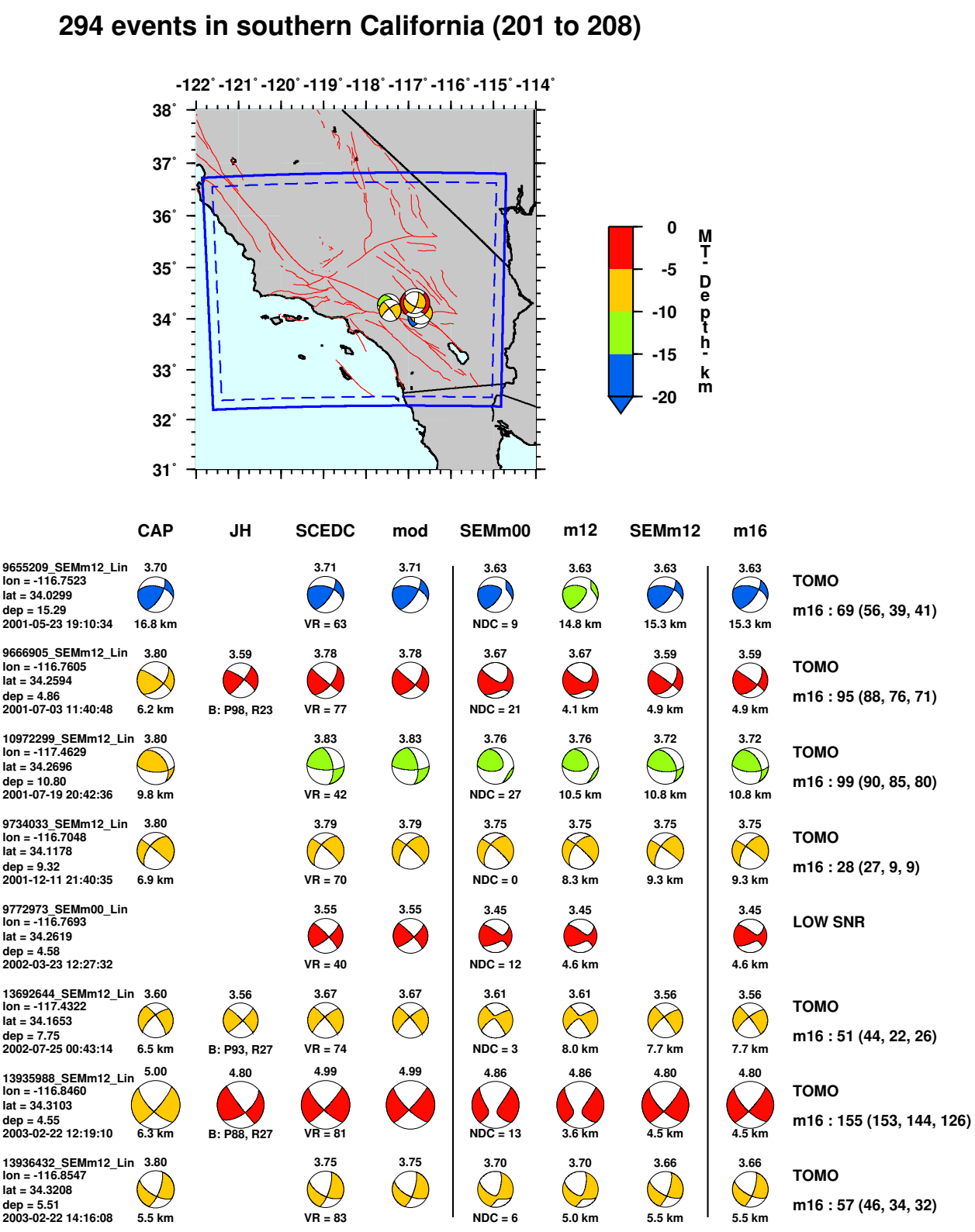

Figure D.26: Source mechanisms considered in the southern California tomography study (201 through 208 out of 294).

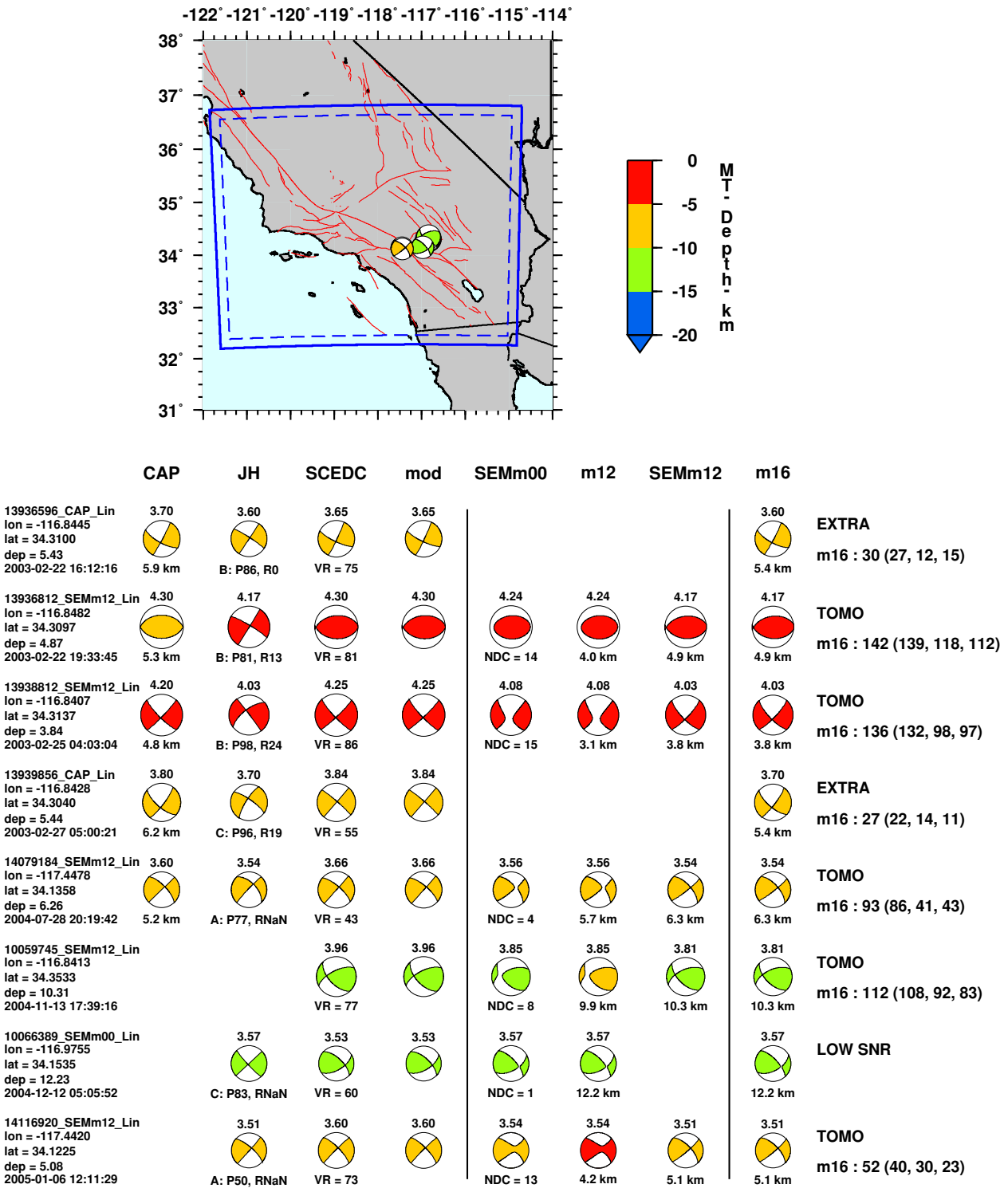

Figure D.27: Source mechanisms considered in the southern California tomography study (209 through 216 out of 294).

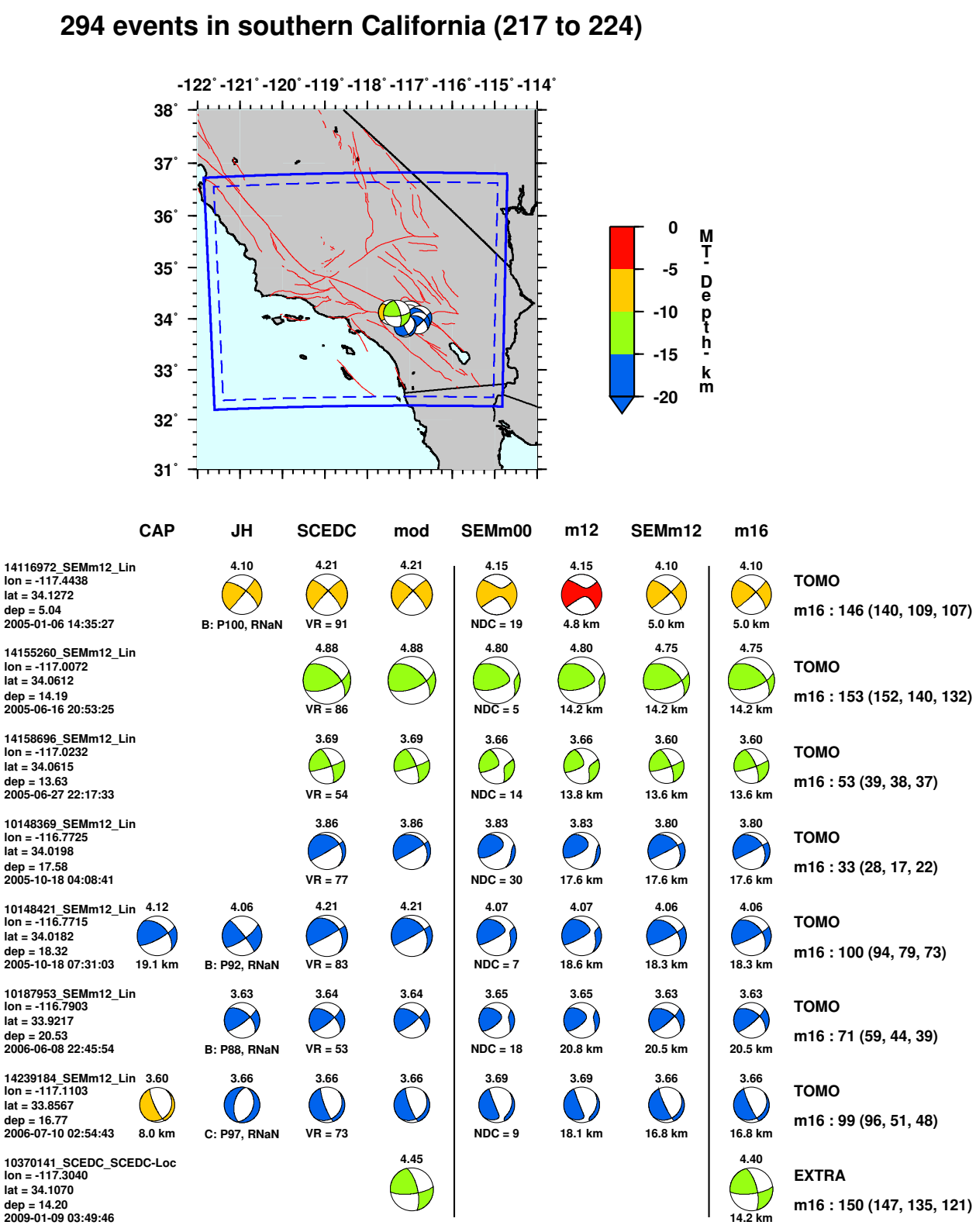

Figure D.28: Source mechanisms considered in the southern California tomography study (217 through 224 out of 294).

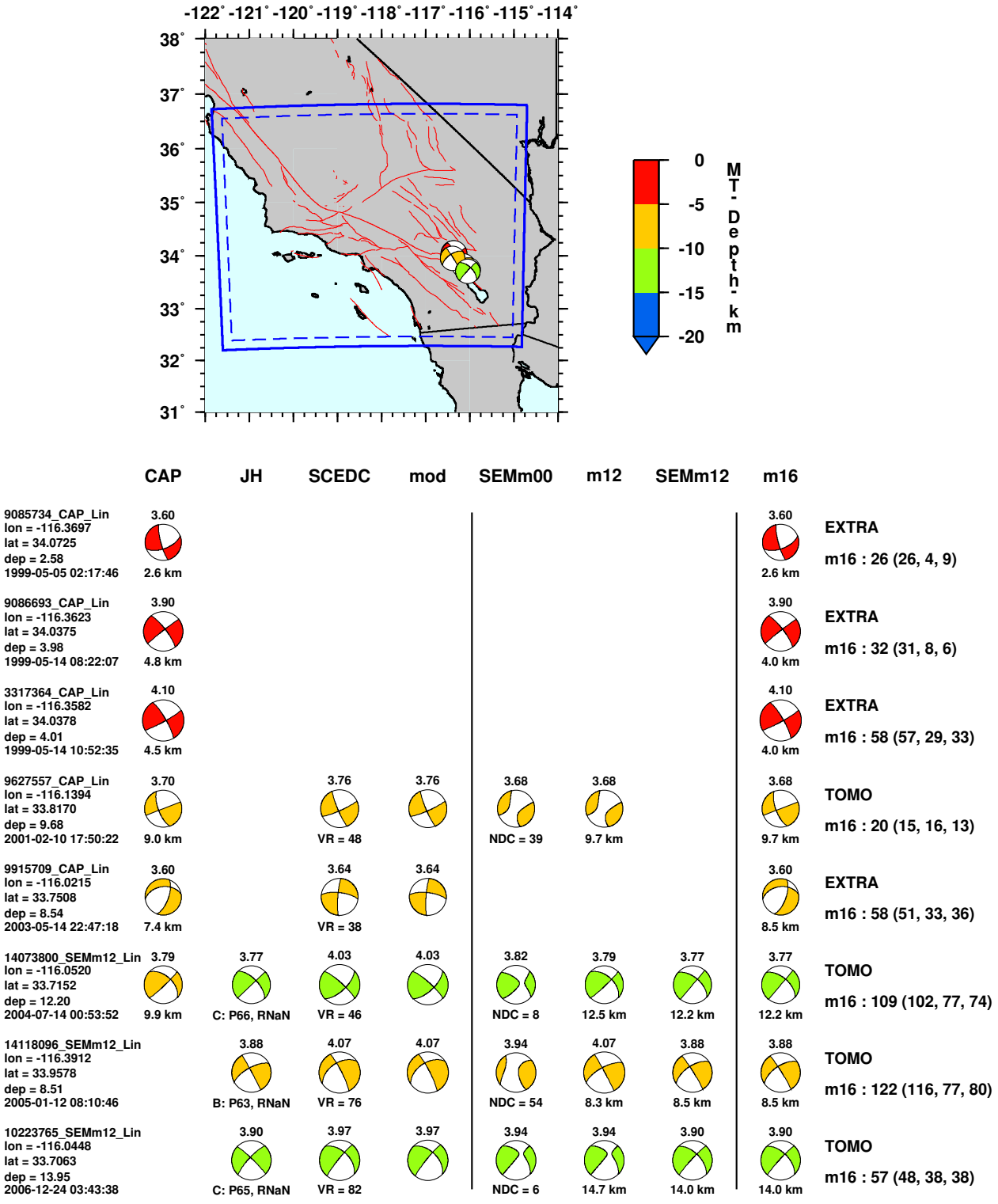

Figure D.29: Source mechanisms considered in the southern California tomography study (225 through 232 out of 294).

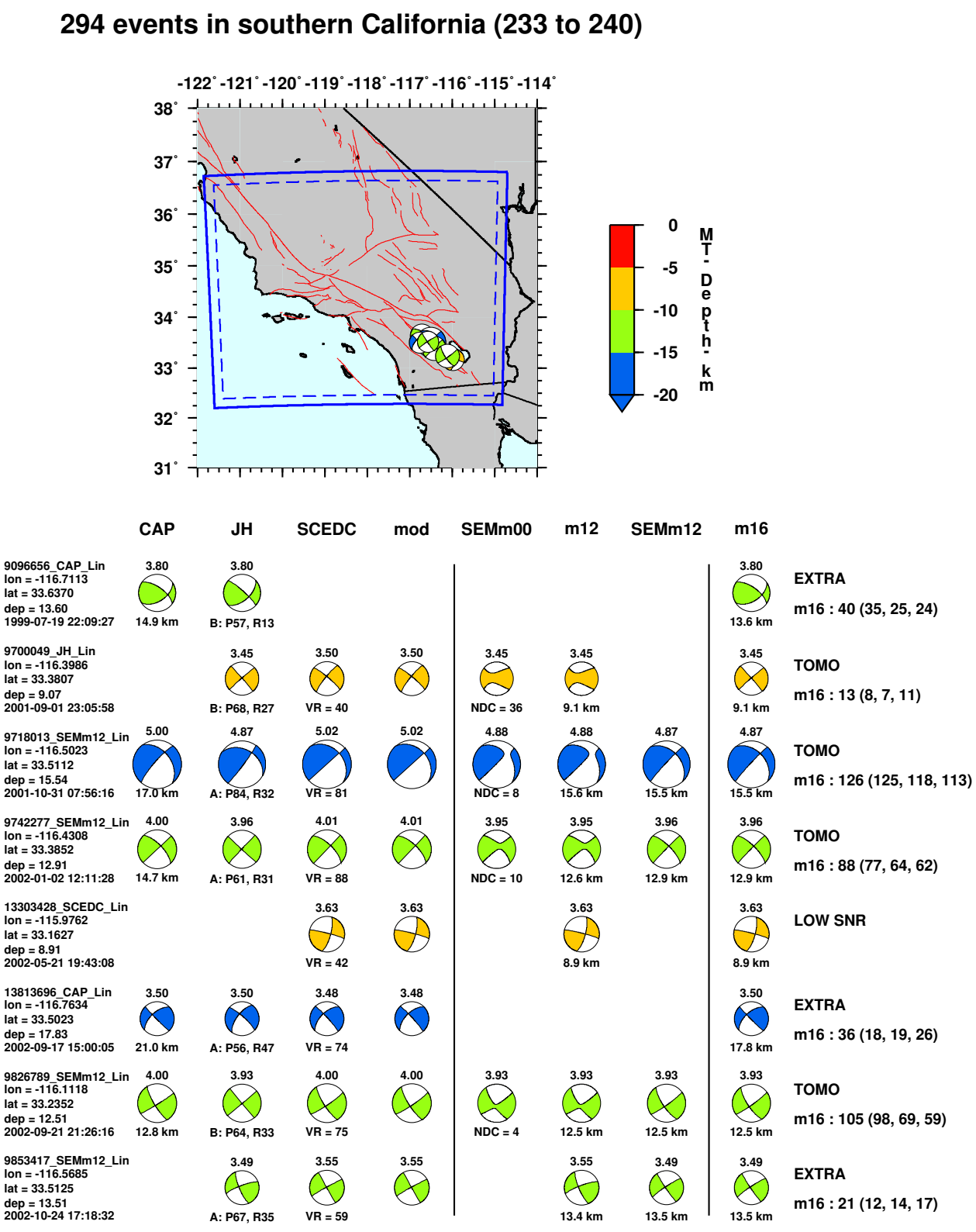

Figure D.30: Source mechanisms considered in the southern California tomography study (233 through 240 out of 294).

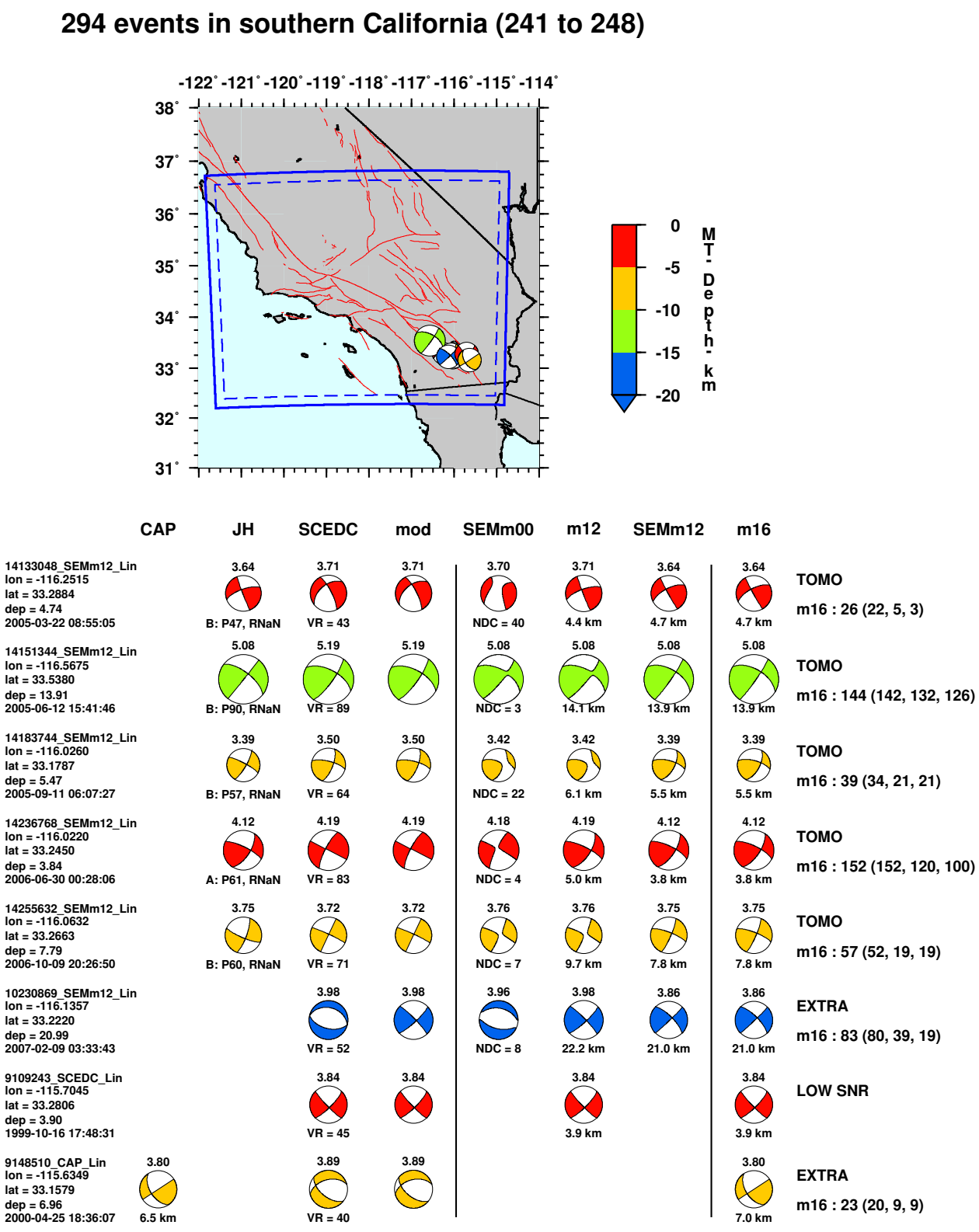

Figure D.31: Source mechanisms considered in the southern California tomography study (241 through 248 out of 294).

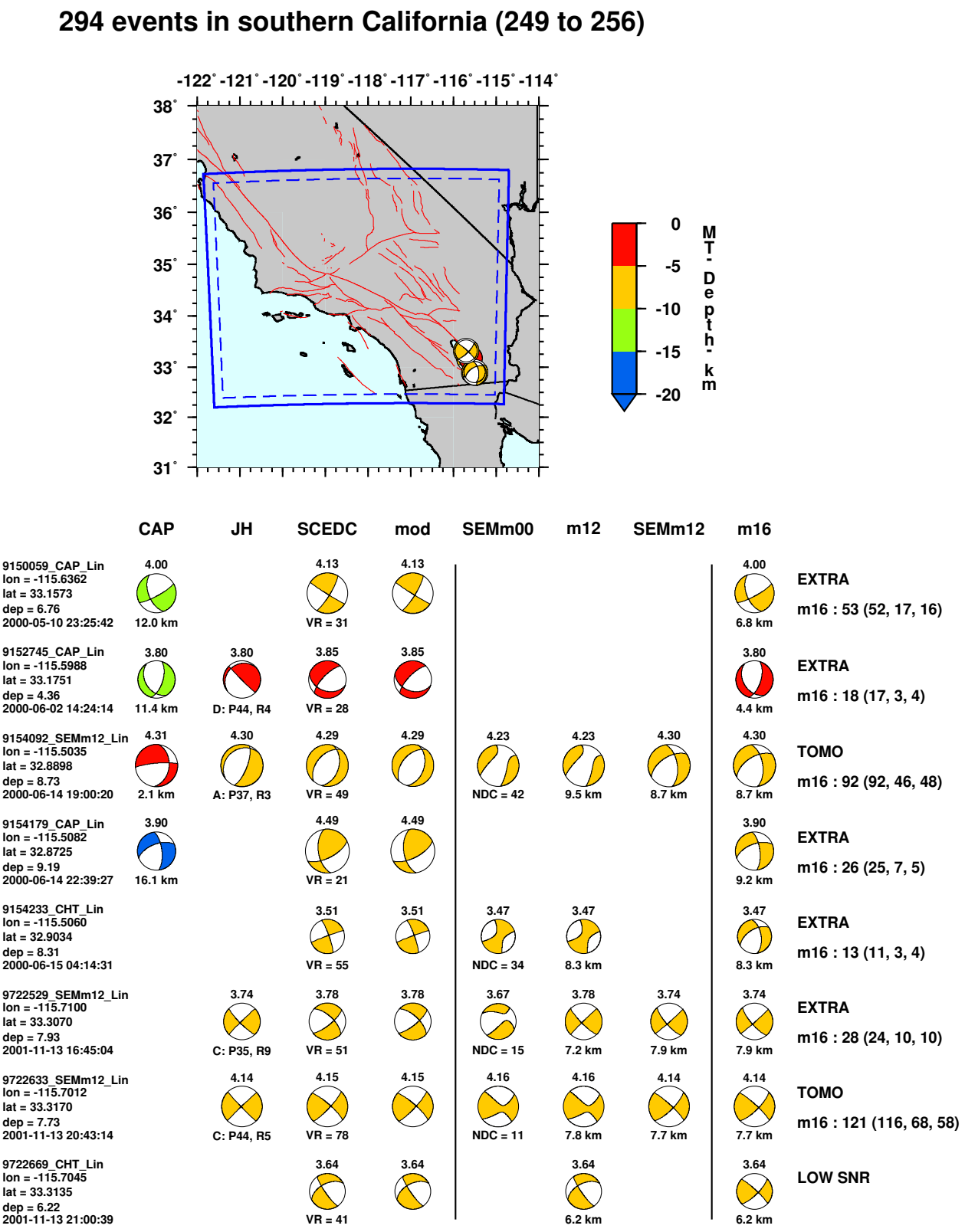

Figure D.32: Source mechanisms considered in the southern California tomography study (249 through 256 out of 294).

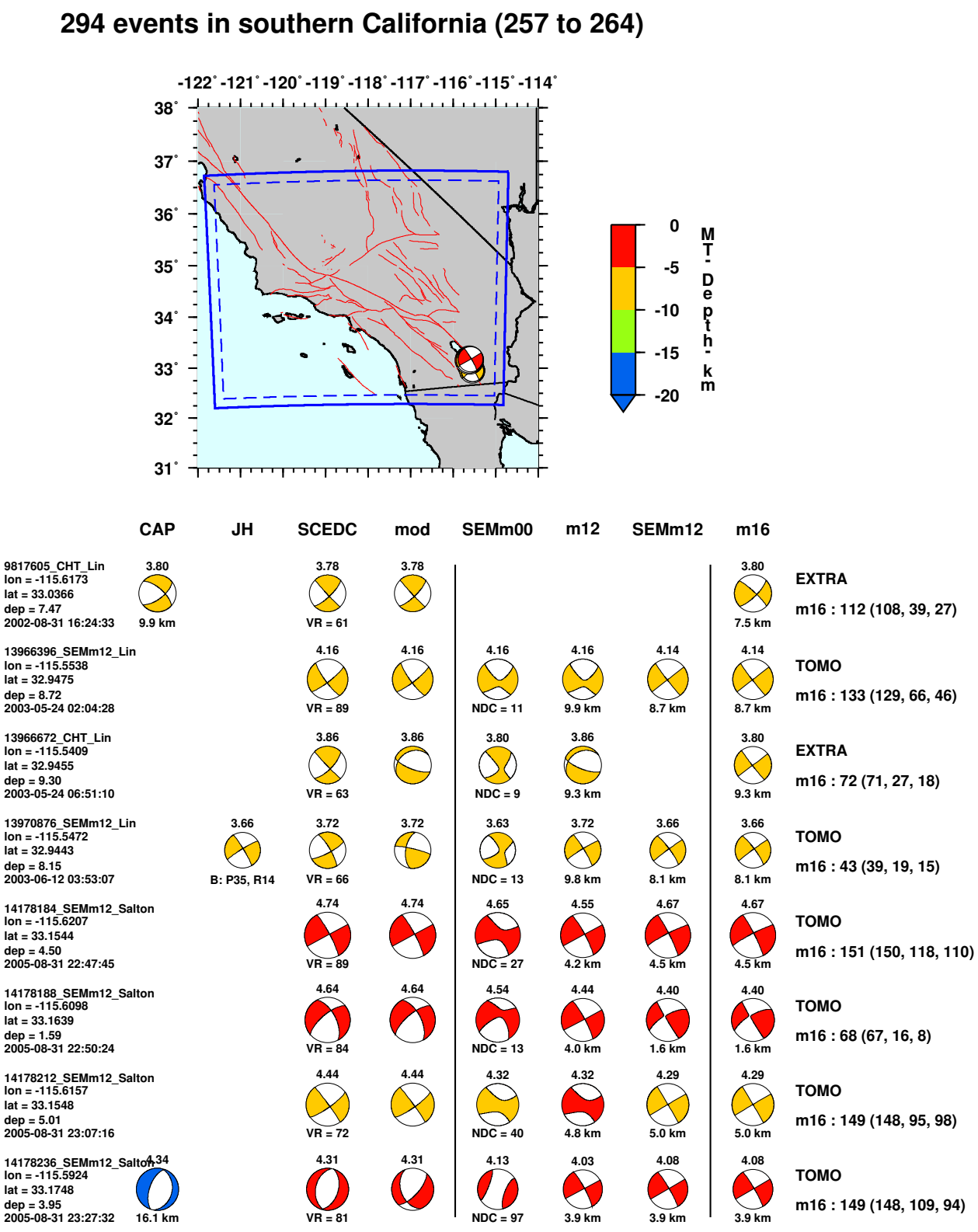

Figure D.33: Source mechanisms considered in the southern California tomography study (257 through 264 out of 294).

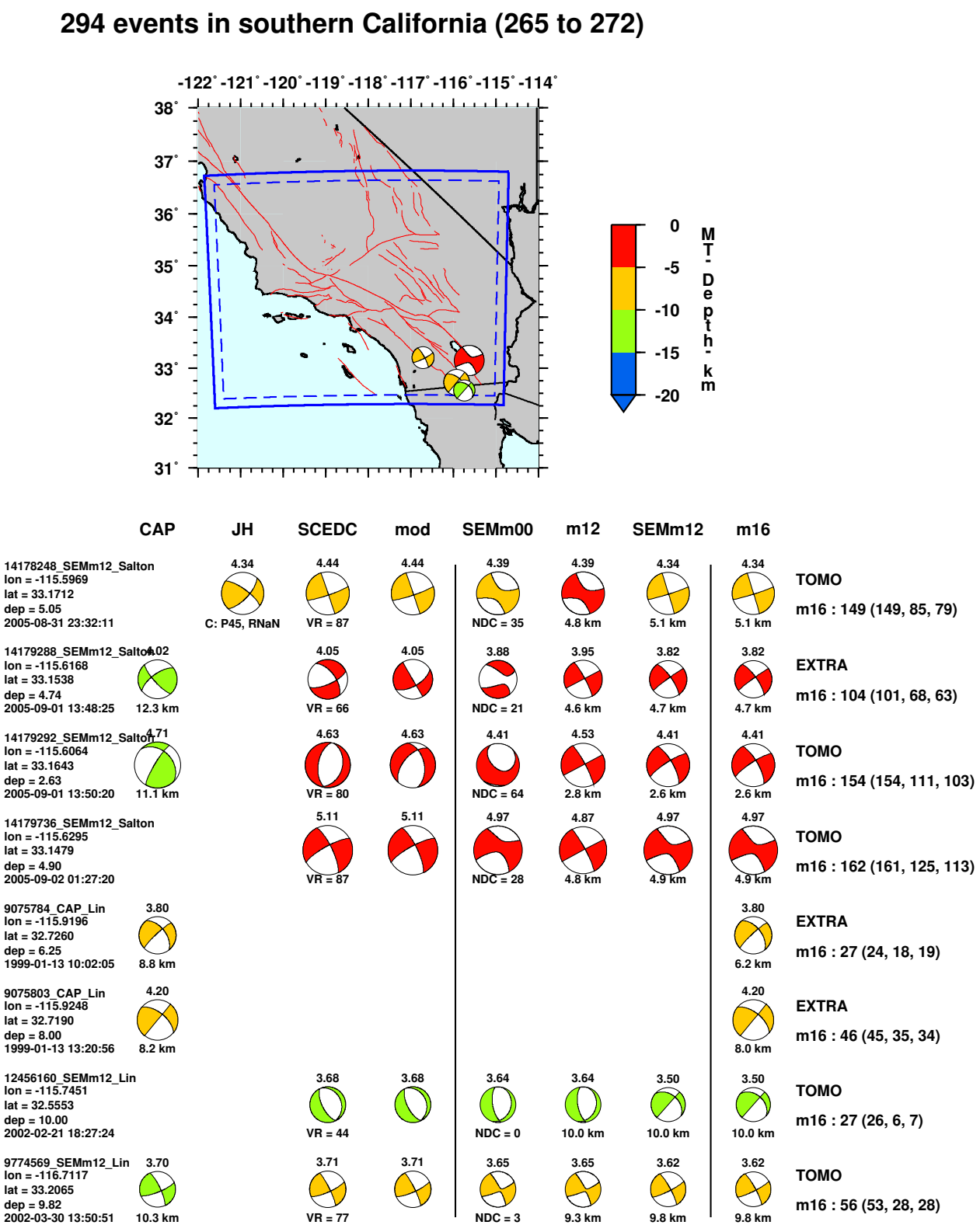

Figure D.34: Source mechanisms considered in the southern California tomography study (265 through 272 out of 294).

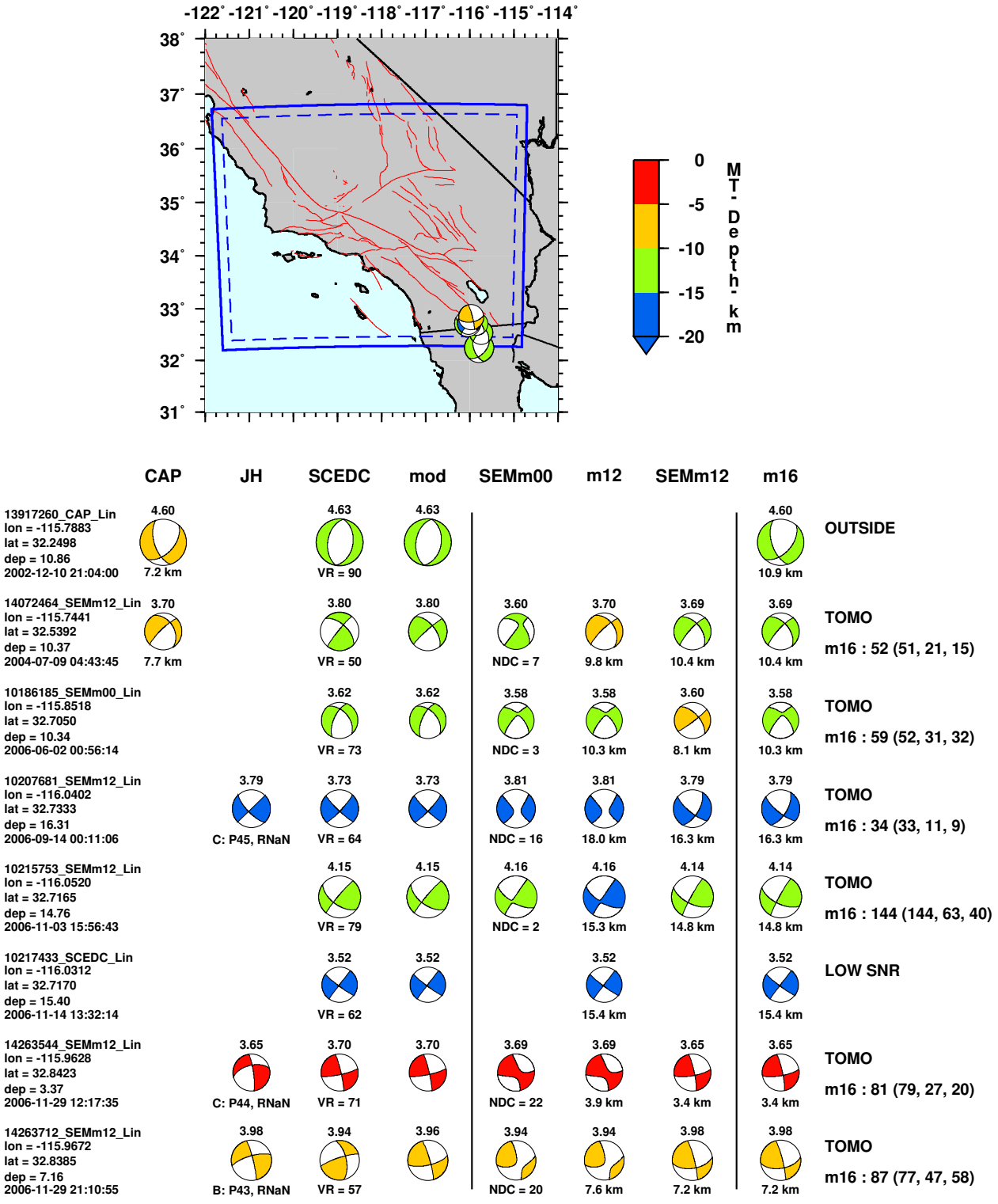

Figure D.35: Source mechanisms considered in the southern California tomography study (273 through 280 out of 294).

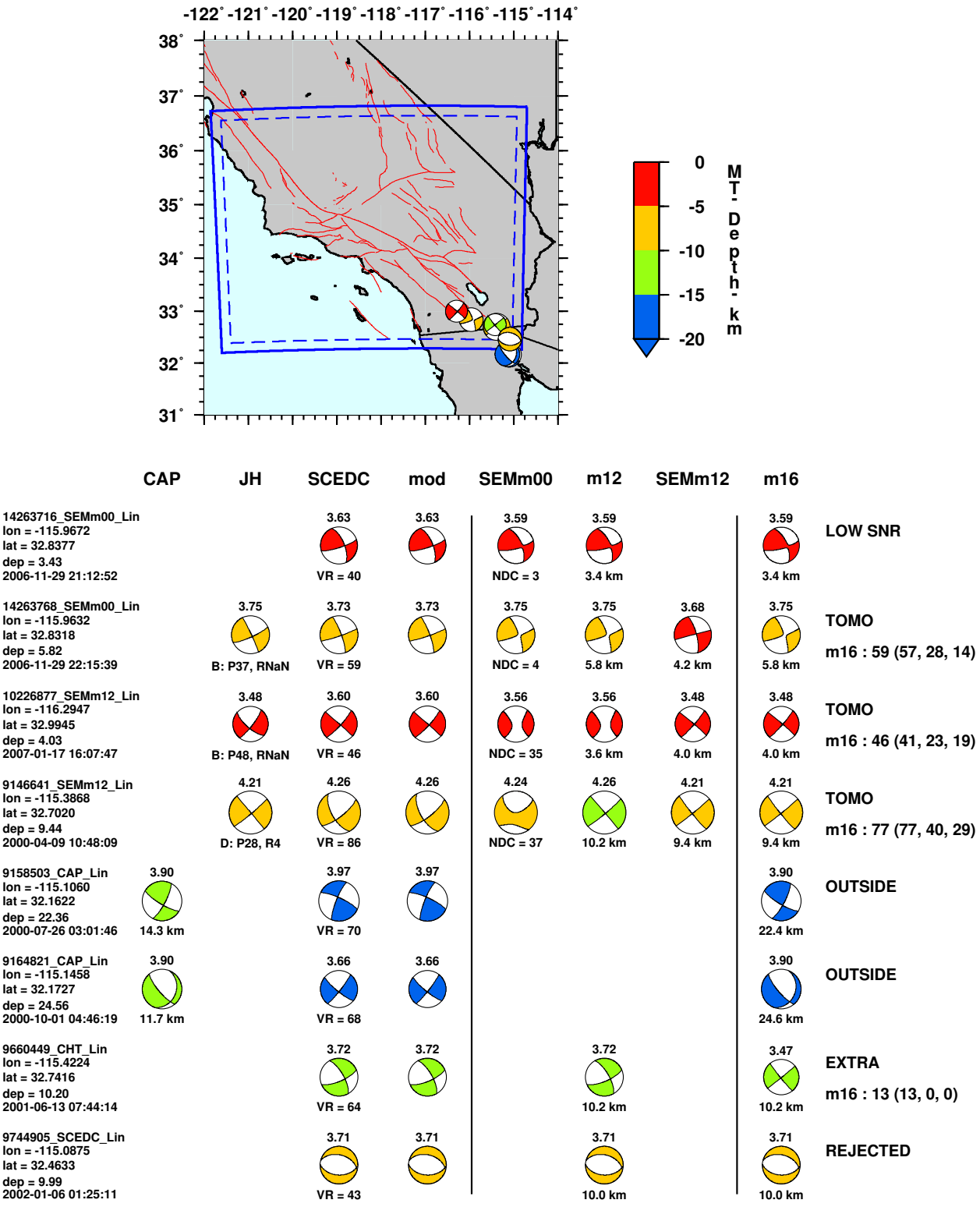

Figure D.36: Source mechanisms considered in the southern California tomography study (281 through 288 out of 294).

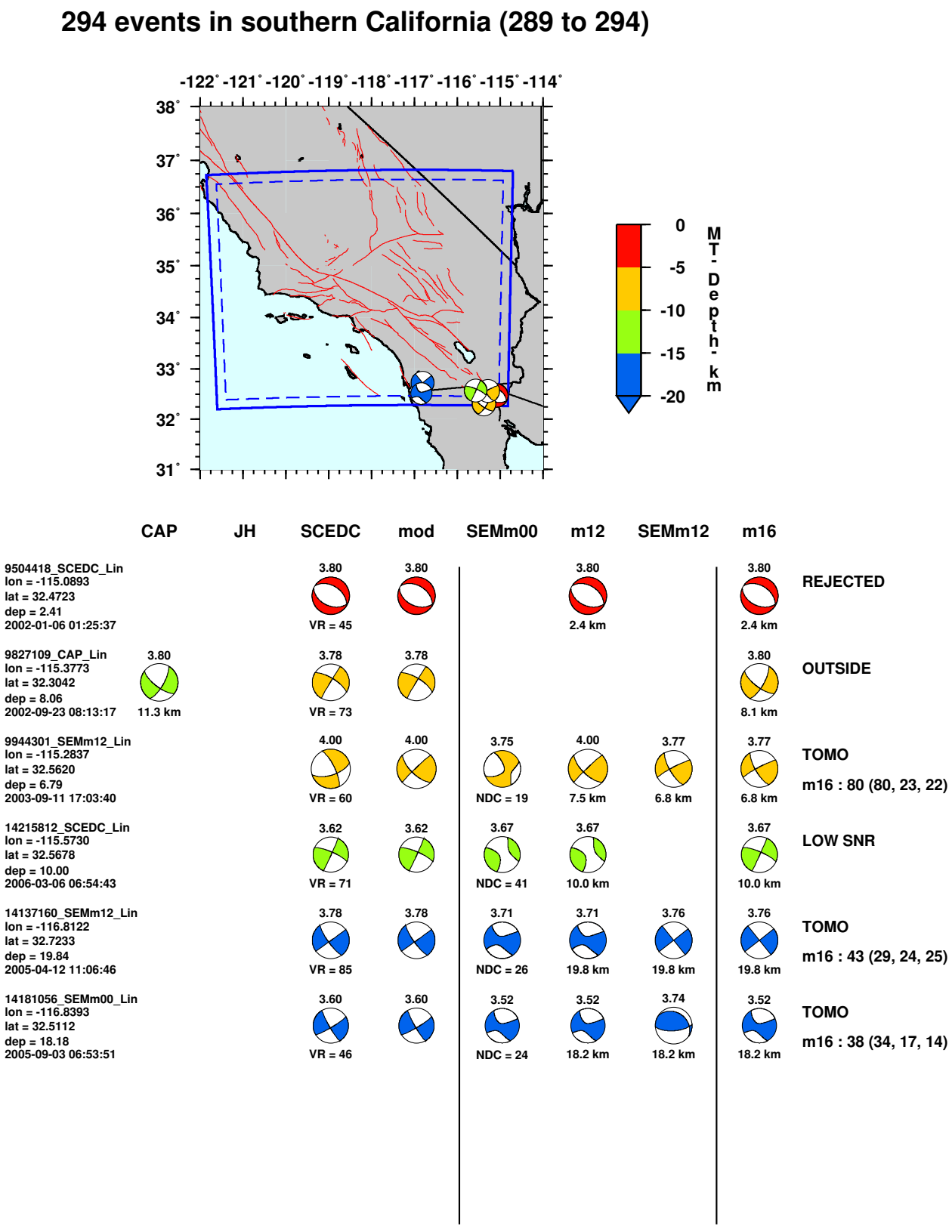

Figure D.37: Source mechanisms considered in the southern California tomography study (289 through 294 out of 294).